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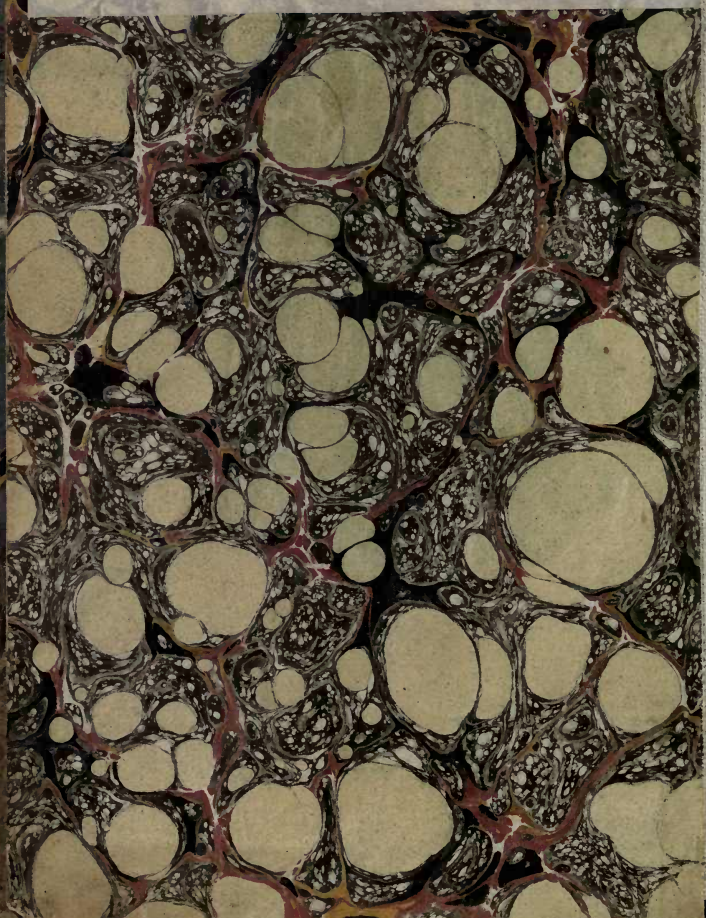

Willats, J. + R., publ. 13

WILLATS'S

SCIENTIFIC MANUALS, No. I.

PLAIN DIRECTIONS

FOR OBTAINING

PHOTOGRAPHIC PICTURES

BY THE

CALOTYPE, ENERGIATYPE,

AND

OTHER PROCESSES ON PAPER;

INCLUDING THE

CHRYSOTYPE, CYANOTYPE, CHROMOTYPE,

ETC., ETC.

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THE favourable manner in which the first edition of this little Work has been received, and the rapidity with which a large impression has been exhausted, have determined the Publishers to reprint it, with such additions and modifications as will render it more generally acceptable. In addition to the instructions for the Calotype and Energiatype, which have been carefully revised, this Manual will contain Directions for conducting all the Photographic processes on paper, which can be of any use to amateurs. The demand for simple and concise treatises on many other branches of science and art, has further induced them to change the general title of the series; and the present Work will therefore appear as NUMBER ONE, OF WILLATS'S SCIENTIFIC MANUALS.

LONDON, 1*st June*, 1845.

17700

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PLAIN DIRECTIONS

FOR

OBTAINING PHOTOGRAPHIC PICTURES BY THE CALOTYPE, ENERGIATYPE, AND OTHER PROCESSES ON PAPER.

THE art of Photography, by which, through the agency of light, the most accurate and beautiful representations of objects are obtained, is the fruit of modern science and research. The darkening of nitrate of silver under the rays of the sun had indeed been long known, but no attempt was made to apply this fact to the purposes of art until 1802, when Mr. T. Wedgewood published a "Method of Copying Paintings upon Glass, and making Profiles by the Agency of Light upon Nitrate of Silver." That eminent chemist, Sir Humphrey Davy, assisted Mr. Wedgewood in his enquiries; but being unable to discover any mode of fixing the images obtained, the experiments were abandoned. About 1814, Mr. Niepce, of Chalons sur Marne, turned his attention to this subject; and in 1827, presented to the Royal Society of London some specimens of pictures produced by the agency of light on glass, copper plated with silver, and highly planished tin: soon after which he entered into partnership with M. Daguerre. The latter gentleman, after repeated, but it would seem fruitless attempts, to prepare a sensitive paper, entered upon those experiments which ended in the discovery of the beautiful process on silver plates which bears his name. In the interval, Mr. Henry Fox Talbot made known the results of his enquiries into the action of light upon salts of silver, in a paper read before the Royal Society in January, 1839, which he followed up in the succeeding month by another, detailing his method of preparing a paper for photographic purposes, and

fixing the designs. This paper was not, however, sufficiently sensitive to be used in the camera-obscura; but Mr. Talbot continuing his experiments, found means to increase the sensibility of his paper, and in 1841 patented the process, to which he has given the name of CALOTYPE, but which has recently (in accordance with the fashionable photographic nomenclature) been termed the TALBOTYPE. Many distinguished scientific men have lately devoted their attention to this subject; and various processes on paper have been from time to time announced by—Sir John Herschel, Mr. Robert Hunt, and others, under the names of AMPHITYPE, ANTHOTYPE, CHROMOTYPE, CHRYSOTYPE, CYANOTYPE, ENERGIATYPE, etc., etc. The first edition of this little work referred to the Calotype and Energiatype only; but we shall endeavour to render our present Manual more complete by such notices of the various processes just enumerated, as their particular merits may seem to require. The Daguerreotype, from its peculiarity and importance, demands a separate consideration, and is made the subject of a distinct number of the present series.* Avoiding, as far as possible, all scientific technicalities, we shall endeavour to give such concise and plain directions as will enable the amateur to obtain the most successful results. Those who may desire to learn something of the philosophical principles involved in the experiments brought under their notice in the subsequent pages, will do well to consult Mr. Robert Hunt's valuable Work, entitled, "Researches on Light," published in the course of the last year.

Before entering on the various processes we are about to describe, we shall briefly notice the apparatus which the amateur will require, in performing this class of photographic operations. Where camera pictures are not desired, it will be simple and inexpensive.

Some camel's-hair brushes, a quire or two of good writing paper, and a few sheets of blotting paper are indispensable. The brushes should be large, the hair collected together in one pencil, and must be, by no means, bound in tin. A separate brush is required for each solution, which should be carefully washed after using. The paper should be carefully selected: to a want of sufficient caution in this respect, must be attributed the constant failures of many experimenters. Whatman's or Turner's superfine yellow or blue wove, is generally recommended, but Moinier's pure white

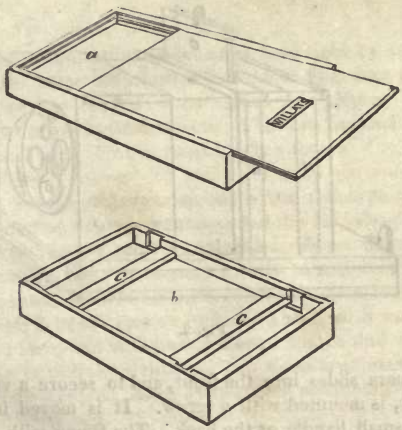
* Photographic Manuals, No. 2. Practical Hints on the Daguerreotype. T. & R. Willats, 98, Cheapside, London.

paper is decidedly the best we have met with. Every sheet should be examined by a strong light, and all those rejected which have any spot upon them, as also those which are found on trial to imbibe the solutions unequally. One side of the sheet should have a pencil mark upon it, by which it may be recognised. The blotting-paper must be the white wove, and the sheets used in different stages of the process should be kept separate. A trough of Berlin Ware, which is not acted upon by chemical preparations, and a slab of the same material are also required for preparing and washing paper.

Copying Frame.

All that is absolutely essential for this purpose, is a piece of plate glass of a sufficient size, and a board of similar dimensions covered with soft flannel: these, with the prepared paper and object to be copied placed between them, may be kept in contact by three or four binding screws. But the most convenient apparatus is represented at Fig. 1, consisting of a frame in which a piece of plate

Fig. 1.



glass (*a*) is fixed, with a wooden back covered with a cushion of flannel. The back may be removed to admit of the introduction of

the paper and object, and when replaced, may be pressed evenly and firmly against the glass by screws (*cc*) placed at the back. A sliding top covering the glass excludes the light, until it is desired to submit the paper to the action of light, or to protect it from change if kept for a short period without setting.

Camera Obscura.

The Camera Obscura adapted for photographic purposes, is a very superior instrument to that commonly sold under the name. The lens may be either achromatic or miniscus.

Willats's Improved Camera, (Fig. 2,)

Which may be used for any photographic purpose, is a box, in the front of which the lens is bedded, by which an increase of light is obtained, the quantity admitted being regulated by a diaphragm, having apertures of different diameter. The back part

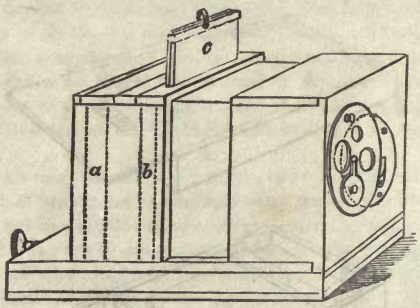


Fig. 2.

of the camera slides into the front, and to secure a very accurate adjustment, is mounted with a screw. It is moved in or out by turning a small handle at the back. The frame with the ground glass (Fig. 3) is furnished with a moveable top and sides, which when extended, exclude the light, and aid the operator in determining the best focus.

The second frame (Fig. 4) consists of a box (*b*), which, when the camera is applied to processes on paper, is made to receive

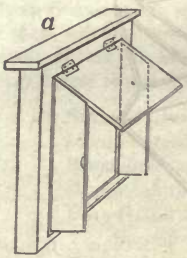


Fig. 3.

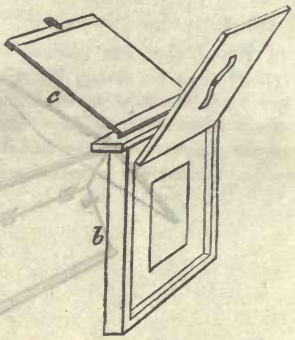


Fig. 4.

a piece of slate, iron, or glass, which is held tight by a spring at the back: this frame is furnished with a sliding door (*c*), laying over the top of the camera when raised. A picture four-inches square may be taken in this camera. The lens is usually 1¾ inch in diameter, and from eight to twelve inches focus.

A Camera more especially adapted to the Calotype process, is now constructed on a plan recommended by Mr. Cundell, whose contributions to the art are very valuable. Two miniscus lenses, each about three inches in diameter, and twenty-four inches in focus, are mounted in a sliding tube, their conjugate foci being as that of a single lens of thirteen inches. These, with an aperture of about 1—3 inch, and with one or more stops behind the lenses, give a picture beautifully defined. The focus is adjusted, and the prepared paper exposed much on the same principle as the other camera above described.

The Camera represented Fig. 5 (next page), is a new and very useful article, being made to fold up into the compass of a moderate

sized book, and may be carried in the pocket without inconvenience.

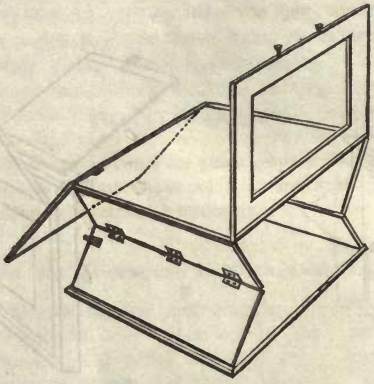


Fig. 5.

It is so arranged as to put together with the utmost ease, and is kept securely in its place by a bolt or two in the sides and back.

The Tripod Staff, (Fig. 6,)

Upon which the camera may be rested when no other suitable

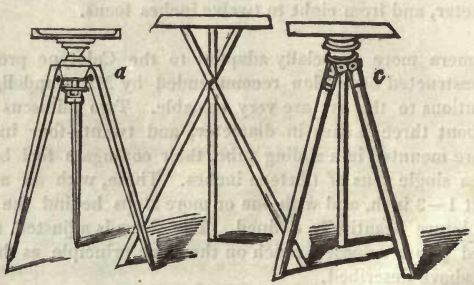


Fig. 6.

place can be found, is a very necessary auxiliary in taking views.

It is about four-feet six-inches high, and carries a small table on which the camera is placed. There are several varieties, differing in their construction and price.

Chemicals.

These should be all of the best quality, and should only be purchased of respectable parties who will guarantee their purity. Cheap chemicals are seldom economical, as the adulteration of any of them will interfere most annoyingly with the successful prosecution of the experiment. The following list comprises almost every article required in the processes hereafter described.

- * Nitrate Silver in chrystals
- Iodide Potassium
- Bromide Potassium
- Hyposulphite Soda
- Pure Gallic Acid
- „ Succinic Acid
- Proto-sulphate Iron
- Ammonia-citrate Iron
- Ferro-sesquicyanuret Potassium
- Yellow Ferro-cyanate of Potash
- By-chromate Potash
- Sulphate Copper
- Nitric Acid
- Strong Ammonia

THE CALOTYPE.

The Calotype, or Talbotype is, as we have already mentioned, the invention of Mr. Fox Talbot. It has been much improved since its first introduction; and to Mr. Cundell in particular we are indebted for many practical suggestions, which he first communicated to the world in the Philosophical Magazine.† In describing this process, we shall, without referring to authorities, give such simple directions for conducting it, as we have found from experience the most likely to produce satisfactory results.

* The Nitrate of Silver in solution is very easily affected by light, and should be kept in a dark place.

† No. 160, May 1844.

Preparation of the Iodized Paper.

Having selected paper of a close and even texture, and fine surface, such as that recommended p. 4, and marked it on one side with pencil, wash this side over carefully with a solution, consisting of 30 grains nitrate silver, dissolved in one ounce distilled water, which apply plentifully with a brush, thoroughly wetting every part, but leaving no moisture unabsorbed; this should be done on a hard smooth board, and thoroughly dried in the dark. Then take a solution of two hundred grains of iodide potassium in half-a-pint of water, to which fifty grains of salt have been added; draw the paper over the surface of the liquid, letting it repose upon it, when plastic, for a few seconds, never more than one minute. After dipping, drain it, and lay it flat until about half dry, then set it afloat in clean water for ten minutes, drawing it now and then along the surface: hang it in the air to dry, and when dry smooth it by pressure. It is of the utmost importance that all the soluble salts should be got out of the paper, and this is readily effected by leaving it floating for a time in water: a rougher washing would loosen the iodide of silver. This paper will keep some time if carefully laid by in a portfolio.

Application of the Gallo-Nitrate of Silver.

Dissolve fifty grains nitrate silver in two ounces of distilled water, to which add one-fifth of its volume of strong acetic acid, very pure. Dissolve also a small quantity of chrystalized *gallic acid* in distilled water, about eight grains to the ounce.* When about to use, mix one part of the latter solution with two parts of the former, mixing however only a sufficient quantity for immediate use, as the resulting liquid decomposes very rapidly. This, and indeed all the operations connected with the calotype, should be conducted in a room from which daylight is entirely excluded: it is indeed preferable to surround any artificial light, which may be used, with a screen of yellow glass, gauze, or paper, the rays which pass through materials of this colour, having little or no influence on the most sensitive preparations. The iodized paper may now be washed evenly over on the prepared side, which may

* A small quantity only of the gallic acid solution should be made at once, as it soon undergoes a change, becoming of a yellow colour, and unfit for use.

be recognised by its pale yellow colour, with the gallo-nitrate mixture, and must then be immediately transferred to clean blotting paper, and all the moisture carefully removed from the surface. A more even distribution of the gallo-nitrate solution may perhaps be obtained by pouring a little out on a slab, and passing the iodized paper over it, taking care that contact in every part is secured, and blotting as before. To save time, the gallic acid may be applied previously, and the paper kept thus half prepared.

Placing in the Camera.

Having prepared the iodized paper as directed above, in which state it is called calotype paper, it should be quickly transferred to the camera frame, enclosed between a plate of slate or iron, and a piece of plate glass to keep it smooth. If the slate or iron be gently warmed, the sensibility of the paper will be increased. The camera must now be put in the proper position, directed towards the object to be copied, and a good clear picture obtained on the ground glass. This picture, when an achromatic glass is used, will give a good working focus; but when the camera is fitted with a miniscus, or any other kind of non-achromatic lens, a peculiar adjustment is necessary to obtain what is called the chemical focus, which differs materially from the optical or visible focus. This chemical focus is about one thirty-sixth part shorter than the other, but the scale should be adjusted according to the lens and camera used. The frame, with the prepared paper, the shutter being perfectly closed, is now placed in the camera. The time of exposure here depends upon so many circumstances, the strength of the light, the colour of the object, the description of lens used in the camera, etc., etc., that it is impossible to give any practical rules upon the subject,—experience will be the best instructor. With a single achromatic lens in the morning sunshine, from thirty to sixty seconds is perhaps requisite for a building, and from one to two minutes for a portrait: in the shade from two to three minutes are required for either. Pictures are taken in a much shorter time, in from ten to twenty seconds, by using a combination of lenses, or with a single lens under very favourable circumstances. The best position for taking a building, is at a distance about twice the measure of its greatest dimension, and from an elevation of about one-third of its height. Where some parts of the building are nearer than others, place the focus to that part which it is most

desirable to have clear, and neglect the others. It is not advisable to take new and old buildings in the same picture, as the time necessary for the old will over-do the new. The sky is frequently overdone, which may be prevented by interposing a black-screen upon the glass over that part which corresponds to it, and which may be previously ascertained by reference to the ground-glass. Portraits should be taken in the open air, but not in the sun. The best uniform back-ground is a blanket, but figures may be grouped in front of a house, or a mass of foliage. There should not be too much white in the dress, as it will be solarized or blotched, before the other parts are distinctly pourtrayed.

Bringing Out the Impression.

When the paper is removed from the frame, always in the dark, nothing is visible; it must then be again washed over with the gallo-nitrate of silver, and exposed to a radiated heat from a gentle fire, or a bottle of hot water,* or to what is still better, a jet of steam, holding the paper vertically before it, never suffering the paper to become in any part perfectly dry. When the picture is, in the opinion of the operator, sufficiently distinct, it must be carefully washed in distilled or rain water, as warm as the finger can bear—the water being changed once or twice, and then dried in blotting-paper.

Fixing Process.

To fix the picture, soak it for two or three minutes, or longer if strongly developed, in a solution of half an ounce of hyposulphite soda to a pint of water, turning it occasionally, and then soak it in water from twelve to twenty-four hours, according to the thickness of the paper, and dry it. The sweetness of the hyposulphite of silver, which is readily communicated to any quantity of water, affords an excellent means of testing when the picture is freed from its influence. It should be washed until the water is perfectly tasteless.

The Calotype process is intended solely for the camera-obscura, and the pictures so obtained are all negative; that is, the lights and shadows are reversed. From these, however, any number of positive pictures, or pictures in which the lights are represented by

* A convenient apparatus for this purpose may be had of Messrs. T. & R. Willats.

lights, and the shades by shades, may be taken in the manner described under the next head.

Mr. Fox Talbot has recently published a method of removing the yellowish tint from pictures taken on calotype and other photographic papers prepared by nitrate of silver, by plunging the picture into a bath composed of hyposulphite of soda, dissolved in ten times its weight of water, and heated nearly to the boiling point. The picture should remain in it about ten minutes, and be then washed in warm water and dried. By this means, he says, the picture is rendered more permanent, and the lights whiter. He also recommends the following means for improving photographic pictures :—

"A copy or reversed impression of a photographic picture is taken in the ordinary manner, except that it remains in the light twice the usual time; its shadows are thus rendered too black, and its lights not sufficiently white. It is then washed and plunged into a bath of iodide of potassium (of the strength of five hundred grains to each pint of water) for one or two minutes, which makes the picture brighter, and its lights assume a pale yellow tint. After this it is washed, and immersed in a hot bath of hyposulphite of soda, until the pale yellow tint is removed, and the lights remain quite white. The pictures, thus finished, have a pleasing and peculiar effect of light and shade, which is not easily attainable by other means."

The transparency of calotype and other pictures may be increased by causing melted wax to penetrate the pores of the paper in the following manner. A small quantity of white wax is scraped on the back of the picture, it is then placed between two other papers, and a hot iron passed over it, which melts and spreads the wax. Or a little boiled oil may be spread over it, and the excess removed by bibulous paper. Canada balsam, or mastic varnish, with turpentine, are very good materials for the same purpose.

It may be necessary to remind the reader, that the CALOTYPE is a patented process. In the two patents obtained by Mr. Fox Talbot, the use of the following processes is claimed as his exclusive right. Some of these claims must, however, be considered invalid, and would possibly affect the value of the entire patents if brought to trial :—

The employment of gallic acid, or tincture of galls, in conjunction with solutions of silver, to render prepared paper more perfect. The obtaining portraits from life by photographic means upon

paper. The employing Bromides for fixing the images obtained. The transferring pictures from one sort of sensitive paper to another. The employment of boiling solutions of hyposulphites, to give increased whiteness to calotype and other photographic pictures; and the process of waxing, when the picture has been rendered more transparent by these means. The process of warming the paper, during the formation of the image, by placing a warm plate of iron behind it to increase the sensibility. The employment of iodized paper excited or rendered sensitive by a liquid, containing only a small portion of nitrate of silver, and subsequently dried; so as to preserve its sensitive state. The varying the lights and shadows of a picture by iodide of potassium, and the fixing the picture so changed. The placing a sheet of white or coloured paper behind photographic pictures after having waxed them. The obtaining enlarged portraits and pictures by throwing a magnified image thereof, by lenses, on photographic paper. The application of photography to printing, by arranging suitable letters or figures, so as to form pages, and making photographic images thereof. The system or combination of the following several photographic processes into one, whereby permanent and perfect copies of the positive kind are obtained, namely, the formation of the negative copy—the fixing it, so that it shall have the requisite transparency, and endure great subsequent exposure to the light—the formation of the positive from the negative copy, and its permanent fixation.

Positive Pictures.

Many attempts have been made to produce positive calotype pictures by a single process, but the methods proposed are all difficult of execution, and rarely successful. The following plan was introduced by Professor Grove, at the last meeting of the British Association held at York. Ordinary calotype paper is darkened until it assumes a deep brown colour, almost amounting to black; it is then re-dipped into the ordinary solution of iodide of potassium and dried. When required for use, it is drawn over dilute nitric acid, one part acid to two-and-a-half parts water. In this state, those parts exposed to the light are rapidly bleached, while the parts not exposed remain unchanged. It is fixed in the usual method. Mr. Grove brought forward, on the same occasion, another process, by which, a negative calotype was converted into a positive one. An ordinary calotype picture is to be taken in the

camera and developed by gallic acid, then drawn over iodide of potassium, and dilute nitric acid, and exposed to full sunshine: while bleaching the dark parts, the light is re-darkening the newly precipitated iodide in the lighter portions, and thus the negative picture is converted into a positive one.

These processes are, as we have said, difficult to manage successfully; and the resulting pictures have, though more minutely defined, and free from many defects inherent to copies through paper, the same disadvantages as those of the Daguerreotype, viz. the positions are reversed, and the copies cannot be multiplied.

A good negative picture having been obtained and carefully set, copies may be procured on almost any kind of photographic paper. The following are the formulas for making the papers commonly used for the purpose. The Energiatype paper, which is also very suitable, is described further on.*

1. Mr. Fox Talbot's Photographic Paper.—Take a sheet of good paper, and having dipped it for a minute or so in a solution of common salt, one part of saturated solution to eight parts of water, dry it first in blotting paper, and then spontaneously. Wash one of the sides, previously marked, with a solution of nitrate of silver—eighty grains to one ounce of distilled water. Allow it to dry, and it is ready for use.

2. Mr. Cundell's Paper.—To a solution of one drachm of nitrate silver, in twelve drachms of water, add strong ammonia, till the precipitate which falls is just re-dissolved. Wash the marked side of the paper over with this solution, then dip it in water containing forty grains common salt to the pint; apply the nitrate of silver solution as before, and dry carefully in the dark.

3. Mr. Cooper's Paper.—Soak the paper for a few minutes in a boiling solution of chlorate of potash, (the strength is immaterial;) dry it, and wash it on one side with a solution of nitrate of silver, sixty grains to the ounce of distilled water. This paper is not very sensitive, but the image can be fixed by washing only.

4. M. Daguerre's Paper.—Immerse the paper in hydrochloric (muriatic) ether, which has become acid from keeping; the

* Iodized, Photographic, and Energiatype Paper, may be obtained of Messrs. T. & R. Willats, 98, Cheapside.

paper is then carefully and completely dried. It is then dipped into a solution of nitrate of silver, and dried without artificial heat in a perfectly dark room. This paper is very sensitive when quite new, but gradually loses its impressionability.

5. BROMIDE PAPER.—Dissolve 100 grains bromide potassium in one ounce distilled water, and soak the paper in this solution. Take off the superfluous moisture, and when nearly dry, brush it over on one side only with a solution of 100 grains nitrate of silver, to one ounce water. This paper is readily prepared, and tolerably sensitive. If required to be very sensitive, it should be brushed over a second time with the nitrate of silver.

These papers really vary very little from each other, and we should recommend Nos. 1, 2, and 5. The same general rules must be observed in the preparation of each. They must all be dried in the dark after the nitrate of silver has been used. If the paper is brushed over, the brush must be large and broad, so that the whole of the sheet may be wetted in two or three sweeps, otherwise marks will appear in the paper corresponding to the lines made by the brush. If blotting paper is required, it must be frequently changed, and never used for two different preparations.

A sheet of either of the above papers may be taken and laid with the marked side upward, on a piece of board covered with flannel: on this paper must be laid the negative picture, with its face downwards, and over both a piece of plate glass, the glass and board being tightly pressed together by screws or weights. The frame described, page 7, is a most convenient apparatus for this purpose. It must now be exposed to light; in about ten or fifteen minutes of bright sunshine, or in several hours of common daylight, a beautiful positive picture is produced, in which the lights and shadows are corrected. These pictures have a fine effect, though they lose somewhat of their sharpness in passing through the copy. They may be set with hyposulphate of soda, as directed for the *negative* pictures. If the negatives are clear, and the shadows dark, a great many copies may be obtained from them.

We may mention here, that copies of PRINTS, FEATHERS, LACE, etc., are obtained in the same manner as the positive pictures just described; and where it is necessary to reverse them afterwards, as in the case of prints, the process must be gone through twice; that is, a strong negative picture must be first obtained, and then

positive copies must be got by printing from it. Beautifully accurate copies of a vast variety of objects may be procured in this way.

Some observations on this subject, which will be found under the head of ENERGIATYPE, will perhaps assist the operator.

ENERGIATYPE.

The process which Mr. Hunt has designated the Energiatype, is one of the simplest and most convenient modes of obtaining photographic pictures; and the public are much indebted to this gentleman for the prompt and handsome manner in which he communicated his discovery, through the pages of the 'Atheneum.'

"While pursuing," he says, "some investigations, with a view to determine the influence of the solar rays upon precipitation, I have been led to the discovery of a new photographic agent, which can be employed in the preparation of paper, with a facility which no other sensitive process possesses. Being desirous of affording all the information I possibly can to those who are anxious to avail themselves of the advantages offered by photography, I solicit a little space in your columns for the purpose of publishing the particulars of this new process. All the photographic processes with which we are at present acquainted, sufficiently sensitive for the fixation of the images of the camera obscura, require the most careful and precise manipulation; consequently, those who are not accustomed to the niceties of experimental pursuits, are frequently annoyed by failures. The following statements will at once shew the exceeding simplicity of the new discovery."

Here follows, in the original letter, the description of the process as then employed. We shall, however, introduce it to the amateur with such modifications as the experience of Mr. Hunt himself, and other gentlemen who have adopted the method, have suggested to us.

PREPARATION OF THE PAPER.—Good letter paper, Whatman's, or Moinier's pure white is best, is first washed over with the following solution, viz.; five grains succinic acid, dissolved in one fluid ounce water, to which is added about five grains common salt

and half a drachm mucilage gum arabic. When dry, the paper is drawn over the surface of a solution of sixty grains of nitrate silver in one ounce of distilled water. Allowed to dry in the dark, the paper is now fit for use, is of a pure white, retains its colour, and may be preserved for a considerable time in a portfolio, until wanted for use.

The preparation of this paper is by no means difficult, but requires much care and attention. The solutions must be applied very equally over the paper, which should be immediately hung upon a frame or clothes' horse to dry. Extreme care must be taken that the paper be not exposed to light, after the nitrate of silver solution has been applied, until required for use. Many of the disappointments experienced by the experimenters on the Energiatype are occasioned by a neglect of this precaution; as, although no apparent effect may have been produced by the exposure, the clearness of the subsequent picture will be seriously injured. The succinic acid must also be very pure. In the general way it will be found more convenient, and perhaps economical, to purchase the paper ready prepared. We shall now briefly describe the method of applying the Energiatype to the different purposes for which it is best adapted, premising that the varying circumstances of time, place, and light, will render necessary such modifications of the following directions as the experience of the operator may suggest. As a general rule, an open situation, sunshine, and, if possible, the morning sun should be preferred, as the image is sharper, and the colour produced more intense, and less effected by the subsequent fixing process.

NEGATIVE PICTURES.

In the Camera.—For a building, an exposure of half a minute in strong sunshine is usually sufficient; for a portrait, which can only be taken in the shade, two or three minutes is required. Directions for placing the camera, sitter, etc., etc. will be found under the Calotype process, at page 13.

Exact copies of prints, feathers, leaves, etc. may be taken, by exposing them to the light in the copying-frame, described, p. 7, until the margin of the prepared paper, which should be left uncovered, begins to turn very slightly. If the object to be copied be thick, the paper must be allowed to assume a darker tint, or the light will not have penetrated it.

Bringing Out the Picture.

When the paper is taken from the camera or the frame, nothing is visible upon it; but by attending to the following directions, the latent picture will quickly develop itself. Having mixed together about one drachm of a saturated solution of *protosulphate of iron* and two or three drachms *mucilage of gum arabic*, pour a small quantity into a flat dish. Pass the prepared side of the paper taken from the camera rapidly over this mixture, taking care to ensure complete contact in every part. If the paper has been sufficiently impressed, the picture will almost immediately appear, and the further action of the iron must be stopped by the application of a soft sponge and plenty of clean water. Should the image not appear immediately, or be imperfect in its details, the iron solution may be allowed to remain a short time; but it must be kept disturbed, by rapidly and lightly brushing it up, otherwise numerous black specks will form and destroy the photograph. Great care should be taken that the iron solution does not touch the back of the picture, which it will inevitably stain, and, the picture being a negative one, render useless as a copy. A slight degree of heat will assist the development of the image where the time of exposure has been too short.

The picture should be carefully washed to take off any superficial blackness, and may then be permanently fixed by being washed with water, to which a small quantity of ammonia, or, better still, hyposulphite of soda has been added. The paper must again be well soaked in clean water, to clear it from the soluble salts, and may then be dried and pressed.

POSITIVE PICTURES.

These are procured in the same manner as the copies of the prints, etc. just described; using the negatives before obtained in place of the objects themselves. Instead, however, of using the iron solution, the paper must be exposed to the light, in the frame, a sufficient time to obtain perfect copies. The progress of the picture may be observed by turning up the corner of the paper, and, if not sufficiently done, replacing it exactly in the same position. They should be fixed with hyposulphite as before directed. It is sometimes better to take negative pictures in the

same way, without using the iron; in which case, the following observations may be useful.

Feathers, if white, or of a light shade, will bear very little exposure; dark feathers may be left until the paper assumes a tolerably deep colour.

Lace.—White lace, net-work, etc. will not bear much exposure, and must be pressed very close to the paper; black lace, etc. may be exposed much longer.

Leaves, Flowers, etc.—These may be advantageously dried and pressed between blotting-paper for a short time before using. They require considerable exposure to produce a perfect copy of the veins and marks: in sunshine from fifteen to twenty minutes,—in ordinary day-light, for three or four hours. They are very beautiful when well executed, and may be coloured to imitate nature very closely.

Wings of Insects, etc.—These being in general very transparent, must not be exposed too long. When the body of the insect has been preserved by drying or dissecting, so as to be tolerably transparent, the following method will secure an accurate copy. Take a light image of the whole insect, and then comparing the copy and the original, cut out those parts which are less transparent than the others, and having placed the object on a fresh piece of prepared paper, cover it with the cut paper, so that the dark parts may be first exposed to light. When these are well delineated, remove the upper paper, and leave the whole exposed till every part is sufficiently pourtrayed. The same plan may be adopted for leaves and flowers, where the parts are of different thicknesses. In copying wreaths of oak or vine leaves, the stem may be replaced by paper cut to imitate it.

Etchings on Glass.—By covering a piece of glass with lamp-black and varnish, a subject may be traced on it with a point, which may be copied on the paper.

Pen and ink sketches on paper may be copied in the same manner.

"The advantage which this process possesses," says Mr. Hunt, "over every other, must be apparent. The papers are prepared in the most simple manner, and may be kept ready by the tourist until required for use: they require no preparation previously to their being placed in the camera, and they can be preserved until

a convenient opportunity offers for bringing out the picture, which is done in the most simple manner, with a material which can be anywhere procured.

It has been found by experiment, that the sulphate of iron has the property of developing the latent images on papers prepared with other salts of silver, and that by using the acetate bromide, benzoate, etc., the most varied and beautiful effects are elicited.

The calotype picture may, it is said, be developed in this way after an exposure of one or two seconds only.

CHRYSOTYPE.

Sir John Herschel, whose various experiments have done so much for the art of Photography, is the discoverer of this process, and that of the Cyanotype, of which we shall next speak. They are both founded upon the use of the salts of iron as photographic agents. The Chrysotype process was communicated to the Royal Society in June, 1843, and is as follows:—

Paper is washed over with a moderately concentrated solution of ammonia-citrate of iron, and dried,—the strength of the solution being such as to dry into a good yellow colour, and not at all brown. In this state it is ready to receive a photographic image, which may be impressed on it either from nature in the camera-obscura, or from an engraving in a frame in sunshine. The image so impressed, however, is faint, and sometimes hardly perceptible. The moment it is removed from the camera, it must be washed over with a neutral solution of gold, of such strength as to have the colour of sherry-wine. Instantly the picture appears; not indeed at once with its full intensity, but darkening rapidly up to a certain point. At this point nothing can surpass the sharpness and perfection of detail of the resulting photograph. The picture is now to be rinsed in spring water, which must be three times renewed. It is then blotted and dried, after which it is to be washed on both sides with a somewhat weak solution of hydriodate of potash. After being again rinsed and dried, it is now perfectly fixed. If the nitrate of silver be used instead of the solution of gold, the picture is brought out more slowly, and with much less beauty.

CYANOTYPE OR FERROTYPE.

This name has been given, by Sir John Herschel, to several processes in which cyanogen is used in combination with iron. The term Ferrotype, which is sometimes applied to them, may with more propriety designate the whole of those photographic processes, a numerous class, in which iron may be employed as the developing agent.

First Process.

The paper is washed over, as in the Chrysotype, with a solution of ammonia citrate of iron. It is now exposed to light, and a latent picture impressed upon it. If the paper has sensibly darkened, the picture will appear negative. It is now brushed over very sparingly and equally with a solution of the ferro-cyanate potash, in which is dissolved a little gum arabic. The negative picture quickly vanishes, and is more slowly replaced by a positive one of a violet blue colour, on a greenish yellow ground. If when dry the details are not sufficiently distinct, a second wash will generally bring out the picture, which should be beautiful and sharp.

Second Process.

A paper is prepared with a mixture of equal proportions of ammonia-citrate iron, and ferro-sesquicyanate of potash. When a picture has been impressed, it is thrown into water, and dried, and a negative picture results. If this picture is washed with a solution of the proto-nitrate mercury, it is readily discharged, but is susceptible of restoration by thoroughly washing out the mercurial salt, and drying the paper. A smooth iron, rather hot, but not sufficiently so to scorch the paper, is now passed over it, and the obliterated picture immediately re-appears, but of a brown tint. These photographs gradually fade and disappear, but may be again restored by the application of heat.

Third Process.

One part by weight of ammonia-citrate of iron is dissolved in eleven parts of water, and this is mixed with an equal quantity of

saturated cold solution of bichloride mercury. Before a precipitate has had time to form, the solution is brushed over paper, which should have a yellowish rather than a blueish cast, and dried. This paper keeps well, and when used is exposed to light, until a faint but perfectly visible picture is impressed. It is then brushed over as rapidly as possible with a saturated solution of prussiate of potash, diluted with three times its bulk of gum water, so strong as just to flow freely without adhesion to the lip of the vessel. The wash must be spread with one application, evenly and very quickly, over every part of the paper. It is fixed by drying. Beautiful positive pictures are thus produced, which will bear immediate exposure tolerably well, but which after a few days will bear strong sunshine uninjured. If the impression be overdone, the darker shades will disappear: if too little, the whole runs into blot. The exact time of exposure can only be learnt by practice.

There are several other varieties of these processes, which are not sufficiently important to be included here: the formula may be seen by reference to Sir John Herschel's Papers in the 'Philosophical Transactions.' The following process communicated by him to the British Association in 1843, is, however, so curious, that we are induced to insert it here. If nitrate of silver, specific gravity 1.200, be added to ferro-tartaric acid, specific gravity 1.023, a precipitate falls, which is in a great measure re-dissolved by a gentle heat, leaving a black sediment, which, being cleared by subsidence, a liquid of a pale yellow colour is obtained, in which a further addition of the nitrate causes no turbidness. When the total quantity of the nitrated solution added, amounts to about half the bulk of the ferro-tartaric acid, it is enough.

The liquid so prepared, does not alter by keeping in the dark. Spread on paper and exposed wet to sunshine (partly shaded) for a few seconds, no impression seems to have been made; but by degrees, although withdrawn from the light, it developes itself spontaneously, and at length becomes very intense. But if the paper be thoroughly dried in the dark (in which state it is of a very pale greenish yellow colour,) it possesses the singular property of receiving a dormant or invisible picture; to produce which (if it be for instance an engraving that is to be copied) from thirty seconds to a minute's exposure in the sunshine is requisite. It should not be continued too long, as not only is the ultimate effect less striking, but a picture begins to be *visibly* produced, which darkens spontaneously after it is withdrawn. But if the exposure be discon-

tinued before this effect comes on, an invisible impression is the result, to develope which all that is necessary is to breathe upon it, when it immediately appears, and very speedily acquires an extraordinary intensity and sharpness, as if by magic. Instead of the breath, it may be subjected to the regulated action of aqueous vapour, by laying it in a blotting-paper book, of which some of the outer leaves on both sides have been damped, or by holding it over warm water.

CHROMOTYPE.

M. Ponton was the first to point out the photographic properties of bichromate of potash. His process for preparing paper is as follows :—Immerse a well-sized paper in a saturated solution of bichromate potash, and dry by the fire. It is of a fine yellow colour, and keeps well in the dark. When exposed to the rays of the sun, it becomes of a light brown ; and if an engraving has been placed upon it, the resulting picture is negative. It is fixed by soaking in water. Mr. E. Becquerel improved upon this process by applying evenly over the paper a sizing of starch, and then steeping it in the bichromate solution as before. The picture having been taken, and the paper washed and dried, it is immersed in a weak alcoholic solution of iodine, in which it remains some time, and is then rinsed and carefully dried between blotting-paper, without much heat. When wet, the shades of the picture are of a fine blue ; but when dry, of a deep violet. If the picture, while wet, is covered with a coating of gum, the colour is better preserved and is more beautiful when dry.

Mr. Hunt announced the process, which is termed the Chromotype, at the meeting of the British Association in 1843. It is not sufficiently sensitive for the camera, but is valuable for copying engravings, etc. Good writing paper is washed over with sulphate of copper, in solution, about one drachm to an ounce of water ; when dry, it is again washed with a strong, but not saturated solution of the bichromate of potash, and again dried. The paper may be preserved in this state for a considerable time. When exposed to sunshine, it changes to a dull brown, and if checked here, a negative picture is produced ; but if the action of light is continued, the browning gives way, and the picture becomes posi-

tive,—yellow on a white ground. From five to twenty minutes is usually required to produce the effect. In either case, if the picture be washed over with a solution of nitrate of silver, a very beautiful positive picture results. To fix the picture, wash it immediately in pure water, and dry it. If the water contains any muriates, the picture suffers, and long soaking entirely destroys it. When a few grains of common salt are added to the water, a curious effect is produced. The picture is apparently rapidly destroyed, but may be restored by an exposure to the sun of from ten minutes to a quarter of an hour, and is now of a lilac colour,—the shades depending on the quantity of salt used. No fresh process is required to fix it.

A beautiful variety of the Chromotype is thus described by Mr. Hunt. "A neutral solution of the chloride of gold is mixed with an equal quantity of the bichromate of potash. Paper is washed with this solution, and dried near the fire. On exposing this paper to light, it speedily changes, first to a deep brown, and ultimately to a blueish black. If an engraving is superposed, we have a negative copy, blue or brown, upon a yellow ground. If this photograph is placed in clean water, and allowed to remain in it for some hours, very singular changes take place. The yellow salt is all dissolved out, and those parts of the paper left beautifully white. All the dark portions of the paper become more decided in their character, and accordingly as the solarization has been prolonged or otherwise, or the light has been more or less intense, we have either *crimson, blue, brown, or deep black photographs of a most beautiful character.*" *

AMPHITYPE.

This is another of the interesting and valuable discoveries of Sir John Herschel. It was given to the public at the last meeting of the British Association, and is described by him as follows:—

Paper, proper for producing an amphitype picture, may be prepared, either with the ferro-tartrate or the ferro-citrate of the protoxide or the peroxide of mercury, or of the protoxide of lead; by using creams of these salts, or by successive applications of the nitrates of the respective oxides, singly or in mixture, to the

* Researches on Light, by Robert Hunt, 1844.

paper, alternating with solutions of the ammonio-tartrate or ammonio-citrate of iron,* the latter solutions being last applied, and in more or less excess. I purposely avoid stating proportions, as I have not yet been able to fix upon any which certainly succeed. Paper so prepared and dried takes a negative picture, in a time varying from half an hour to five or six hours, according to the intensity of the light; and the impression produced varies in apparent force from a faint and hardly perceptible picture, to one of the highest conceivable fulness and richness, both of tint and detail, the colour in this case being a superb velvety brown. This extreme richness of effect is not produced except lead be present, either in the ingredients used, or *in the paper itself*. It is not, as I originally supposed, due to the presence of free tartaric acid. The pictures in this state are not permanent. They fade in the dark, though with very different degrees of rapidity, some (especially if free tartaric or citric acid be present) in a few days, while others remain some weeks unimpaired, and require whole years for their total obliteration. But though entirely faded out in appearance, the picture is only rendered dormant, and may be restored, changing its character from negative to positive, and its colour from brown to black (in the shadows) by the following process:—A bath being prepared by pouring a small quantity of solution of pernitrate of mercury into a large quantity of water, and letting the sub-nitrated precipitate subside, the picture must be immersed in it, (carefully and repeatedly clearing off all air bubbles,) and allowed to remain till the picture (if anywhere visible) is entirely destroyed, or if faded, till it is judged sufficient from previous experience; a term which is often marked by the appearance of a feeble positive picture, of a bright yellow hue, on the pale yellow ground of the paper. A long time (several weeks) is often required for this, but heat accelerates the action, and it is often complete in a few hours. In this state the picture is to be very thoroughly rinsed and soaked in pure warm water, and then dried. It is then to be well ironed with a smooth iron, heated so as barely not to injure the paper; placing it, for better security against scorching, between smooth clean papers. If then the process has been successful, a perfectly black positive picture

* So commonly called, and sold as such; but as I am disposed to regard their composition, their chemical names would be ferro-tartrate and ferro-citrate of ammonia.

is at once developed. At first it most commonly happens that the whole picture is sooty or dingy to such a degree that it is condemned as spoiled; but on keeping it between the leaves of a book, especially in a moist atmosphere, by extremely slow degrees this dinginess disappears, and the picture disengages itself with continually increasing sharpness and clearness, and acquires the exact effect of a copper-plate engraving on a paper more or less tinted with pale yellow. I ought to observe, that the best and most uniform specimens which I have procured, have been on paper previously washed with certain preparations of uric acid, which is a very remarkable and powerful photographic element. The intensity of the original negative picture is no criterion of what may be expected in the positive. It is from the production, by one and the same action of the light, of either a positive or a negative picture, according to the subsequent manipulations, that I have designated the process thus generally sketched out, by the term *amphitype*,—a name suggested by Mr. Talbot, to whom I communicated this singular result; and to this process, or class of processes, (which I cannot doubt when pursued will lead to some very beautiful results,) I propose to restrict the name in question, though it applies even more appropriately to the following exceedingly curious and remarkable one, in which silver is concerned. At the last meeting I announced a mode of producing, by means of a solution of silver, in conjunction with ferro-tartaric acid, a dormant picture brought out into a forcible negative impression by the breath or moist air. The solution then described, and which had, at that time, been prepared some weeks, I may here incidentally remark, has retained its limpidity and photographic properties quite unimpaired during the whole year since elapsed, and is now as sensitive as ever,—a property of no small value. Now, when a picture (for example an impression from an engraving) is taken on paper washed with this solution, it shows no sign of a picture on its back, whether that on its face be developed or not; but if, while the actinic influence is still fresh upon the face, (*i. e.* as soon as it is removed from the light,) *the back* be exposed for a very few seconds to the sunshine, and then removed to a gloomy place, a *positive picture, the exact complement of the negative one on the other side*, though wanting of course in sharpness if the paper be thick, *slowly and gradually makes its appearance* there, and in half an hour or an hour acquires a considerable intensity. I ought to mention that the "Ferro-tartaric acid" in question is prepared by precipitating the ferro-tar-

trate of ammonia (ammonio-tartrate of iron) by acetate of lead, and decomposing the precipitate by dilute sulphuric acid.

P. S. When lead is used in the preparation of Amphitype paper, the parts on which the light has acted are found to be in a very high degree *rendered water proof.*

ANTHOTYPE.

The influence of light upon the growth and germination of plants is very curious and interesting. The facts connected with this subject have been investigated by Mr. Chevrieul, Mr. Hunt, and Sir John Herschel. To the latter gentleman we are indebted for the enquiries which have led to the publication of the Anthotype process. He found that the expressed juices, and alcoholic or watery infusions of certain flowers, more particularly the papaver rhœas, the coschoous taponica, the violet rose, ten weeks' stock, etc. etc. when spread on paper, were very sensitive to light. To procure this colouring matter, the petals of fresh and well-selected flowers are bruised to a pulp in a marble mortar, either alone or with the addition of a small quantity of alcohol,—the juice is expressed by squeezing the pulp through a piece of fine linen. The paper is prepared in the following manner:—"The paper should be moistened on the back by sponging and blotting off. It should then be penned on a board, the moist side downwards, so that two of its edges (suppose the right hand and lower one) shall project a little beyond those of the board. The board being then inclined twenty or thirty degrees to the horizon, the alcoholic tincture (mixed with a very little water, if the petals themselves be not very juicy) is to be applied with a brush, in strokes from left to right, taking care *not to go* over the edges which rest on the board, but to pass clearly over those that project; and observing also to carry the tint from below upwards by quick sweeping strokes, leaving no dry spaces between them, but keeping up a continuity of wet spaces. When all is wet, cross them by another set of strokes from above downwards, so managing the brush as to leave no floating liquid on the paper. It must then be dried as quickly as possible over a stove, or in a current of warm air, avoiding however such heat as may injure the tint." If

alcohol has not been added, the extract must be applied to the paper immediately. Most of the papers so prepared require an exposure of many days, from twenty to thirty, to produce a decided effect, and the pictures obtained are not always permanent. This will of course preclude their being of practical utility; but the changes produced are so remarkable, that we could not, with propriety, omit mentioning them. A full account of Sir John Herschel's experiments will be found in his Memoir, or "The Action of the Rays of the Solar Spectrum on Vegetable Colours," etc. published in the second part of the Philosophical Transactions for 1842.

Similar effects are produced by light in the gums resins and residua of essential oils, when thin films are spread upon paper or on metal plates. A paper prepared with an alcoholic solution of guaiacum, and placed in an aqueous solution of chlorine, acquires a beautiful blue colour; it is very sensitive, and may be used for copying engravings, the resulting picture penetrating the paper, and appearing on the back with almost the same intensity as on the face. The images, however, speedily fade.

In the preceding pages we have endeavoured to include all the Photographic processes which will be really useful to amateurs. There are many varieties of all these; every successful practitioner having his favourite formula, or modus operandi. To record all those that have been announced to the world, during the last two or three years, would require a volume, and would confuse rather than direct. We would recommend our readers to acquire a practical acquaintance with such as have been described; and then, if they have some chemical knowledge, a small portion of time devoted to the consideration of the general principles upon which they are all conducted, will possibly enable them to introduce divers modifications and improvements. We have already pointed the way to such enquiries, in referring to Sir John Herschel's papers in the Philosophical Transactions, and to Mr. Robert Hunt's Researches on Light, which, with a few papers scattered through some of our scientific periodicals, comprise everything of importance that has been written on the subject.

WILLATS'S ENERGETIC FLUID,

FOR PRODUCING INSTANTANEOUS PICTURES WITHOUT THE AID OF IODINE OR BROMINE.

THIS Fluid, perhaps the most active of the various preparations ever offered to the public as accelerating agents, is used as a single solution; and with due precaution in polishing the plate, and observing the colours, is almost invariable in its results. The mixture, consisting of 1½ drachms of the fluid in 2 ounces water, should be poured into a shallow trough to about a quarter inch of the top. The plate will generally assume the proper colour in from four to six minutes; if not, the mixture is too weak, and more of the fluid must be added. The brown, or deep rose colour gives the most rapid picture, and the blue the softest; intermediate tints should be carefully avoided. With a double lens, a portrait or view may be taken instantaneously in the sun, or in from one to five seconds in the shade, according to the degree of light. With a single lens, it will require one second in the sun, and from five to ten seconds in the shade. A longer exposure will only injure the strength and beauty of the picture. It is not generally understood that a sensitive plate, exposed to the action of light in the camera, is rapidly impressed with a picture, which strengthens up to a certain point, when it begins to fade, and is almost entirely effaced, when a negative picture forms, and at length becomes permanent. These changes have not yet been accurately observed, but there is reason to believe that the process alluded to is gone through several times in one minute. This fact, which may be easily proved by experiment, may account for the failures which some persons have experienced in using the Energetic Fluid. Having exposed the plate too long, until the picture has passed the proper stage, and commenced to darken, they conclude that it has not been sufficiently exposed, and acting under this erroneous impression, they increase the time, until every proof becoming worse than the preceding, the use of the Fluid is abandoned.

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Willats's Improved Photographic Camera, with Best Achromatic Lens 1¾ in. diameter, mounted in Brass Front, with variable diaphragm, fine screw adjustment Frame, with ground glass disc, and folding shutters, for obtaining the focus, shifting frame adapted for taking three various sized pictures, either by the Daguerreotype or Calotype processes.....	3	10	0
Ditto Ditto with compound set of achromatic Lens	6	6	0

This apparatus has the advantage of serving with all sorts of object glasses, whether simple or compound, and for all sizes of plates: its construction is very simple, and not likely to get out of order.

"PHOTOGRAPHY.—A Camera on an improved principle, for taking photographic portraits and views, has been invented by Mr. Willats, 98, Cheapside, which, upon examination, will be found much superior to that in ordinary use. We have heard many complaints of the common camera, the insufficiencies of which we think Mr. Willats is in a fair way to remedy. The camera invented by him is of superior value, inasmuch as it can be adjusted with much greater facility and certainty; and so obviates, in a great degree, the trouble often occasioned by the old instrument. We have examined some of the pictures executed by means of the improved camera, and find them most perfect, even to the minutest detail."—*Art Union, August*, 1844.

Willats's Improved Photographic Camera, packed in case, complete with every requisite, to enable the Tourist to take correct sketches from the varied and beautiful scenes in nature, and also well adapted for delineating portraits with the greatest accuracy, consisting of Mercury, Plate and Chemical Boxes, (which contains a full supply of the necessary preparations) Iodizing and Bromine Pans, Polishing Block and Velvet Buffs, Washing Tray and Stand, Brass Stand with adjusting screws, Spirit Lamp, Etna, prepared cotton wool, with Directions	10	10	0
Ditto Ditto with double combination of achromatic lenses	14	0	0
Small Photographic Cameras, with sliding tube, and Periscopic or Plano convex lenses, adapted either for the Daguerreotype, Calotype, or Energiatype processes	1	1	0
Do. Do. with Achromatic Lens	1	5	0
„ with rackwork adjustment	1	15	0
„ with calotype chemicals and apparatus	2	10	0
„ with Daguerreotype apparatus and materials, complete in case	5	5	0
Second size do. with achromatic lens, and sliding tube	1	15	0
„ „ with rackwork adjustment	2	2	0
„ „ with calotype chemicals and apparatus	3	16	0
„ „ with Daguerreotype apparatus, and materials complete in case	6	10	0
Photographic Camera, with best compound achromatic lens 1¾ in. diameter	5	10	0
Ditto ditto, complete in case, with every requisite for obtaining Daguerreotype pictures 2¾ by 3¼	10	0	0
Ditto, ditto, with best compound lens, 2 in diameter	6	6	0
Ditto, ditto, complete with additional apparatus, chemicals, &c. for obtaining pictures by the Daguerreotype processes, from 2½ by 2 to 4 by 3 inches	14	14	0
Portable Folding Camera, with achromatic lens, rackwork adjustment, &c. from	4	4	0

This form of Camera is exceedingly convenient, being made to fold up into the compass of a moderate size book, and may be carried in the pocket without inconvenience.

Lerebour's Parisian Apparatus, with the latest improvements from	5	15	0
Cundell's Photographic Cameras, as described in the Philosophical Magazine, with double miniscus lenses	3	3	0

Voitglander's Double Combination of Achromatic Lenses, 3 in. diameter, mounted in brass cells, and tube with rack-work adjustment		20	0	0
Ditto Ditto 2 inches diameter		10	10	0
Ditto Ditto 1¾ — diameter		6	6	0
Double Combination of achromatic lenses of very superior English manufacture, of corresponding curvature to Voitglander's, mounted in brass front, with rack-work adjustment, 4 in. diameter		15	15	0
Ditto Ditto 3 in. diameter		10	10	0
Ditto Ditto 2 in. diameter		4	4	0
Ditto Ditto 1¾ in. diameter		3	10	0

The advantage gained by using the double combination of achromatic lenses over the single arrangement is, that they are far more rapid in their operation, and give a much sharper picture.

Achromatic lenses, 1 inch diameter, 4 inch focus, and upwards		0	6	0
Do. 1 inch diameter, 5 inch focus,		0	8	0
Do. 1 „ 6 „		0	10	6
Do. 2 „ 6 „		0	14	0
Parallel Mirrors mounted in brass frames, to attach to the front of the Camera, for reversing the pictures,		1	1	0
Prisms for Ditto Ditto.				

Plano Convex, Periscopic, Miniscus, and every description of Lens required in Photographic Experiments.

Brass Camera Fronts, with rackwork adjustment for Lenses,—1 inch, 1¼ inch, 1½ inch, 1¾ inch, and 2 inch. Prices,—11s. 12s. 14s. 15s. ..... to		0	18	0
Brass Camera Fronts, with sliding tube for 1-inch lens .		0	6	0
Ditto 1¼-inch lens		0	7	0
Ditto 1½-inch lens		0	9	0
Ditto 1-inch lens		0	10	0
Ditto 2-inch lens		0	12	0
Brass Camera Fronts, with revolving diaphragm, on which are apertures of different diameters for regulating the intensity of the light, according to the nature of the picture, 1¼ in.		0	7	0
Ditto Ditto 1½ in.		0	9	0
Ditto Ditto 1¾ in.		0	10	6
Ditto Ditto 2 in.		0	15	0
Mercury Boxes for small Cameras		0	13	0
Ditto Ditto. 15s.		0	18	0
Ditto Ditto best construction, with cast iron				

cistern, sliding front and legs, and coloured glass windows for viewing the development of the picture	1	4	0
Ditto Ditto with Thermometer, ... from	1	11	0
Plate Boxes to contain a supply of plates in mahogany or walnut wood.			
Ditto for 2½ × 2 in plates.....	0	4	0
Ditto for 3¼ × 2¾ „	0	5	0
Ditto for 4 × 3 „	0	5	6
Ditto in Japanned Metal.			
Ditto for 2½ × 2 in. plates.....	0	1	9
Ditto for 3¼ × 2¾ „	0	2	6
Ditto for 4 × 3 „	0	3	0
Iodizing and Bromine Pans made of hard glazed porcelain, with air-tight slate covers .... each	0	2	0
Ditto Ditto in mahogany or walnut cases, with three frames for holding the various sized plates	0	10	0
Ditto, with levelling screws and plate-glass covers ..from	1	1	0
Dark Coloured Glasses for the Bromine Solutions, or Chloride of Iodine ..... from	0	4	0
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Polishing Block for holding the plates during the polishing process	0	3	6
Plate Holders .....from	0	1	6
Glass Spirit Lamps .....each 2s. 3s. and	0	4	0
Brass Ditto. ....each	0	3	6
Brass Stands for supporting plates, ...2s. 6d. 3s. 6d. to	0	5	0
Ditto. with levelling screws..... from	0	5	6
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Portable Folding Tripod Stand, with table to fix on top .....from £1 1s. to	1	15	0
Common Do. Do. .. 9s. 6d. to	0	16	0
French Pattern Double Folding Tripod Stand, with table, etc.	2	2	0
This Instrument is exceedingly firm and steady.			
Glasses to indicate from five seconds to one minute, in Leather case.....each	0	2	6
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Finely Carded Cotton Wool .....per ounce	0	0	4
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Graduated Glass Syringes for dosing the Bromine..	0	2	0

Claudets, Brass Frames, for retaining prepared plates each ..... 10d., 1s. and	0	1	2
Improved ditto, of Japanned Tin, with covers.....	0	2	0
Prepared Gold Beater's skin, for fastening pictures in frames.			
Pressure Frame and glass, for obtaining positive Photographs, or copying Engravings, Lace, Leaves, etc. etc. ..... from	0	5	0
Ditto Ditto with sliding lid..... from	0	7	6
Portable Rectangular Frame, for preparing the Sensitive Paper	0	2	0
Ditto ditto	0	5	0
Earthenware Trays for washing and setting pictures	0	2	0
Camel's Hair Brushes, ... 1s., 2s.	0	2	6
Tin Vessels for heating Calotope drawings, ...3s. and	0	5	0
Photogenic Paper, in packets .....1s. and	0	2	6
Iodized Paper, in packets .....1s. and	0	2	6
Energiatype Paper, in packets .....1s. and	0	2	6
White Wove Blotting Paper .....per quire	0	1	6
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Moinier's Pure White Paper...	0	1	6
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Silvered Plates warranted of the best English manufacture—

2½ inches by 2 inches.....per doz.	0	12	0
3¼ „ 2¾ „ ..... „	0	18	0
4 „ 3 „ ..... „	1	7	0
5 „ 4 „ ..... „			
Do. do French or German, 3¼ by 2¾..per doz.	0	12	0
Do. do. do. 4 by 3 „	0	18	0

If less than a dozen are taken, the prices will be rather higher.

Skeleton Frames to contain Daguerreotype Pictures—

Common do. with black line border on paper, for plates, 2½ by 2.....8d. to	0	1	0
Do. do. 3¼ by 2¾ .....9d. to	0	1	0
Do. do. 4 by 3 .....1s. to	0	1	4
Do. painted on glass with black line border for plates, 2½ by 2 .....10d. to	0	1	2

Common do. painted on glass with black line border for plates, 3¼ by 2¾ ..... 1s. to	0	1	8
Do. do. 4 by 3 .....1s. 3d. to	0	1	9
Best do. with ornamental gilt borders of various forms and patterns, for plates..... 2½ by 2, 1s 4d. to	0	1	8
Do. do. 3¼ by 2¼ .....1s. 6d. to	0	1	9
Do. do. 4 by 3 .....1s. 9d. to	0	2	6
Leather Cases, with oval, square, or dome top, gilt mats and glasses complete, for portraits .. ..2 by 2½	0	2	0
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Hyposulphite Soda .....per oz.	0	0	6
Chloride Gold Solution ..... 2s. 6d. and „	0	5	0
Chloride Gold Chryst. .....per grain	0	0	3
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——— Rouge ..... „	0	0	6
——— Emery ..... „	0	0	6
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Rulman's Sensitive Solution ....per bottle	0	2	6
Hyposulphite Gold Solution ..... per oz.	0	0	3
Hyposulphite Gold Chryst..... per grain	0	0	3
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Pure Succinic Acid	„	0	10	0
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Pure Chloride Lime	„	0	0	6
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Proto Sulphate Iron	„	0	0	4
Gum Arabic	„	0	0	6
Oil of Cloves	„	0	4	0
„ of Cassia	„	0	5	0
„ of Lavender	„			
Hyposulphite Soda	„	0	0	6
Pure Cyanide Potassium 1s. or	„	0	2	0
Iodide Potassium	„	0	3	0
Chloride Potassa	„	0	0	6
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PRACTICAL HINTS

ON

THE DAGUERREOTYPE.

NOTWITHSTANDING the many valuable discoveries with which the researches of Sir John Herschell, Mr. Fox Talbot, Mr. Robert Hunt, and other distinguished philosophers, native and foreign, have recently enriched the science of Photography, or, as it is now termed, Actino-Chemistry,* the Daguerreotype process, first divulged in 1839, still retains the highest place in public estimation. The extreme beauty and delicacy of the pictures produced by this method, and the comparative simplicity and certainty of the operation, fully justify this preference, and account for the large number of amateurs who are pursuing it in the present day, with more or less success. While, however, the process is simple in itself, it requires much care and nicety of manipulation, which is only to be acquired by continued practice, or by the most careful attention to the directions which are given by proficients in the art,—and without which the operator is exposed to frequent annoyance and disappointment. It is with the view of providing this necessary assistance, that the following Hints have been thrown together, in which all technicalities have been as much as possible avoided, and the directions made short and plain, so as to be easily understood and followed.

The history of this invention is well known: Monsieur Daguerre had for some time devoted his attention to the subject of Photography, particularly to the means of fixing the images obtained in the camera obscura. While pursuing these enquiries in conjunction with his partner, Mr. Niepcée, he was led to adopt an entirely new

* This term was suggested by Sir John Herschell, and adopted at a Meeting of the British Association, in September, 1844, to indicate that department of Chemistry which is connected with the influence of the solar rays.

process, which, after many years of study and experiment, was produced under the name of the Daguerreotype. The French government appreciating the utility of invention, purchased it for the benefit of all nations, granting to M. Daguerre a pension of 6,000 francs per annum for his life, and a proportional sum to M. Isidore Niepcée, the son of his former partner. Since the introduction of the Daguerreotype, very many improvements have been introduced, chiefly with a view to increase the sensibility of the plates, on which the effect of light is now, with fine lenses, almost, if not quite, instantaneous.

As the possession of a good apparatus is an essential attribute of success in taking Daguerreotype pictures, it will be well to begin by describing the various articles which are necessary or convenient for this purpose. They are as follows:—

Camera Obscura.

The Camera Obscura, used for taking Daguerrotype Pictures (Fig. 1,) is a wooden box, furnished in front with a brass tube, in which an achromatic lens is made to slide. The image is received on a piece of ground glass fitted in a frame, which slides in a groove in the back of the camera, and the focus is adjusted by a rack-work in the brass tube of the lens. The frame and glass may be withdrawn, and another frame introduced,—consisting of a wooden back, made to hold the silver plate, and a sliding front which can be raised when the plate is to be submitted to the action of the rays of light passing through the lens. This Camera may be made of any dimensions, according to the diameter of the lens employed.

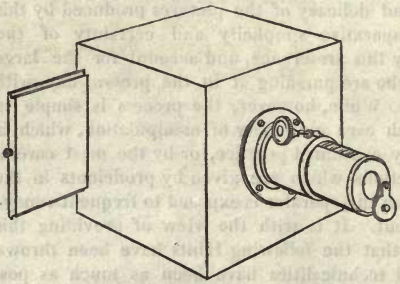


Fig. 1.

Willats's Improved Photographic Camera, (Fig. 2,)

Is a great improvement on that just described. The lens,

instead of sliding in a brass tube, is bedded in the front of the Camera, by which an increase of light is obtained, the quantity admitted being regulated by a diaphragm having apertures of different diameter. The back part of the camera slides into the front and, to secure a very accurate adjustment is mounted with a screw. It is moved in or out by turning a small handle at the back. This camera is arranged with two grooves (*a* and *b*), so as to allow the use of two lenses of different focal powers, according as portraits or views are desired.

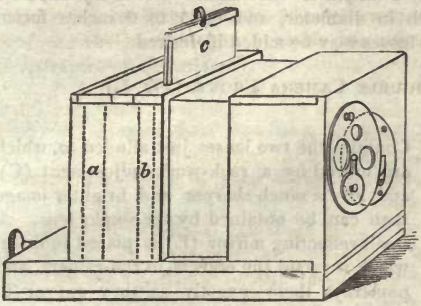


Fig. 2.

The frame with the ground glass (Fig. 3) is furnished with a moveable top and sides, which when extended, exclude the light, and aid the operator in determining the best focus.

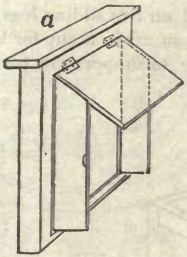


Fig. 3.

The second frame, (Fig. 4) consists of a box (*b*) made to receive thin wooden frames adapted to the various sized daguerreotype plates, which may be placed horizontally or vertically, at pleasure:—this frame is furnished with a sliding door (*c*), laying over the top of the camera when raised.

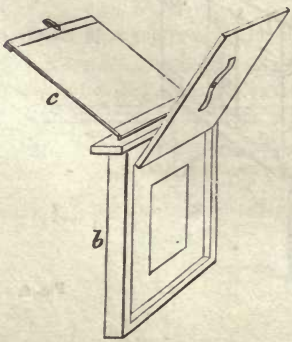


Fig. 4.

These cameras are usually made about 8 inches broad by 6½ high, and will carry a 4 by 3-in. plate. The lenses of a very superior quality are of 1¾ inch in diameter, and of 5 to 6 inches focus. Double combination lenses may be added if desired.

The Double Camera Front, (Fig 5,)

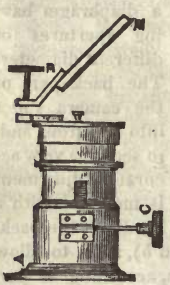


Fig. 5.

Contains the two lenses just alluded to, which are moved by a rack-work adjustment (C), and give a much sharper and brighter image than can be obtained by the single lens. A small reflecting mirror (E) is placed in front, which reverses the objects in the camera, and pourtrays them exactly as they appear in nature. This combination is far more rapid in its operation than the single lens.

Mercury Box.

This is a small box (Fig. 6) supported on two sliding legs, for the sake of portability, having in the bottom an iron cup for holding the mercury, and in the inside a ledge to support the frame.

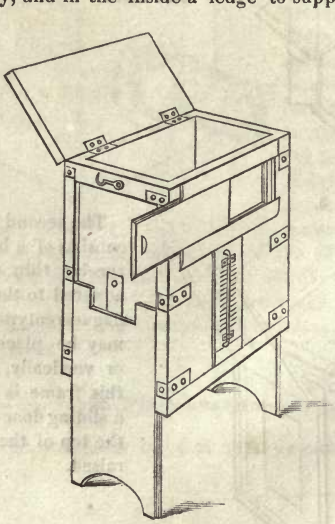


Fig. 6.

and plate. In the front is introduced a piece of glass, protected by a slide, to enable the operator to watch the developement of the picture. A small thermometer is usually added, the bulb of which dips into the iron trough, to enable the operator to observe the temperature of the mercury.

Iodine and Bromine Troughs, (Fig. 7.)

These are either of glass or Berlin ware, encased in wood; they are furnished with frames of various sizes to hold the plates, and with a cover of slate or glass. They may be used for any of the sensitive solutions.

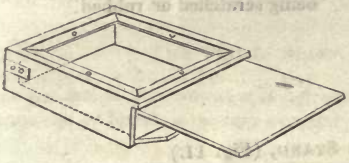
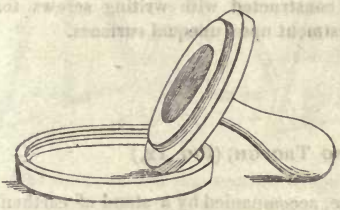


Fig. 7.

Polishing Block with Cover, (Fig. 8.)



This block is made of a shape and size convenient to the hand:—the plate adheres firmly to the prepared surface of the block, but may be readily disengaged when the process of polishing is completed.

Fig. 8.

The Buff, (Fig. 9,)

Consists of a piece of wood of suitable dimensions, generally about twelve inches by three, covered with several folds of white cotton velvet, thoroughly cleansed from dirt, or grease.

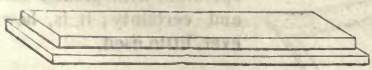


Fig 9.

Plate Box, (Fig. 10.)

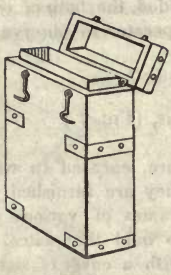


Fig. 10.

These boxes are of wood, or japanned metal, fitted with grooves which prevent the plates from touching each other:—they are very necessary to prevent the plates from being scratched or rubbed.

Fixing Stand, (Fig. 11.)

Fig. 11.

This is a wire stand, made to support the plate in an horizontal position, while heat is applied in the fixing process: it is also constructed with writing screws for adjustment upon unequal surfaces.

The Washing Trough, (Fig. 12,)

Is of metal, or Berlin ware, accompanied by a stand of earthenware, by which the frame is supported in the proper position while washing. An apparatus has been constructed for performing this operation with greater ease and certainty; it is, however, little used.

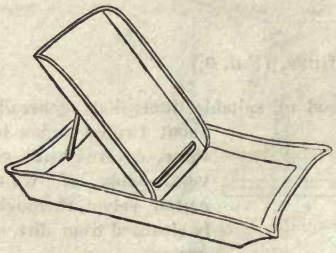


Fig. 12.

Claudet's Frame and Improved Ditto.

Both these frames are used for carrying prepared plates. The first is a thin metal frame, of the same dimensions as the plates it is intended to carry, and is placed between them to keep them from the light, and to prevent their touching each other, or gathering dust. In this state they may be tied together, and carried in the pocket without danger. The second is the same frame in a metal case, which closes tightly, and still more effectually secures them from light, dust, or contact.

The Tripod Staff, (Fig. 12,)

Upon which the camera may be rested, when no other suitable place can be found, is a very necessary auxiliary in taking views; it is about 4 feet 6 inches high, and carries a small table on which the camera is placed.

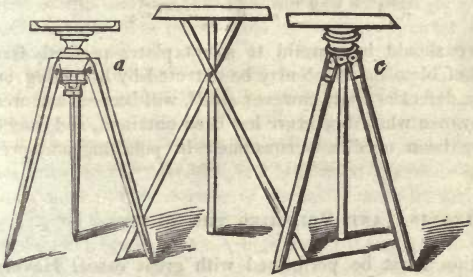


Fig. 12.

There are several varieties, differing in their construction and price.

The operator will also require a spirit lamp, with a large wick, for heating the mercury, etc., etc.

Cotton Wool, which must be thoroughly clean, and free from grease.

Prepared Tripoli, or Rotten Stone.

Prepared Lamp Black.

Olive Oil and Alcohol.

Chloride of Iodine.

One or other of the various sensitive solutions.

Distilled Mercury.

Hyposulphite of Soda.

Chloride of Gold, or Hyposulphite of Gold.

Frames of various sizes and patterns are made for mounting the Daguerreotype Pictures with or without cases.

DESCRIPTION OF THE PROCESS.

We shall now proceed to describe, briefly and clearly, the Daguerreotype process, as practised by the most successful operators of the day, omitting such variations as are not essential to the production of good proofs, and which tend rather to confuse than instruct the amateur, but not knowingly discarding anything which can facilitate his progress. And first, a remark or two on the silver plates, upon which the picture is obtained.

These plates are made expressly for the Daguerreotype. There are several sizes, the more useful of which are as follows:—

No. 1	..	2	by	2½	inches.
„ 2	..	2¾	„	3¼	„
„ 3	..	3	„	4	„
„ 4	..	4	„	5	„

The purchaser should be careful to select plates perfectly free from any kind of blemish, which may be detected by breathing on the plate, as a defect or spot, however small, will become a source of great annoyance when a picture has been obtained, and much time will have been needlessly consumed in polishing and preparing them.

Cleaning and Polishing the Plates.

This operation must be performed with great care. Having fixed the plate on the plate-holder, shake over it some finely powdered tripoli, or rotten-stone, add a small quantity of pure alcohol, and with a piece of prepared cotton proceed to rub the plate with a rapid circular motion, taking care not to press upon it with much force:—the paste formed by the alcohol and tripoli, must then be well cleaned off with fresh wool and dry tripoli, and the above process repeated two or three times, until a clean surface of pure silver is obtained. This is the best plan for a new plate:—if the plate has been used before, and the picture has not been what is termed fixed, the above operation will suffice; but if it has been fixed, it is sometimes necessary to use a little olive oil with the tripoli in the first instance, and then proceed with the tripoli and alcohol as before. The plate is now ready for polishing, which is best performed by rubbing the plate rapidly over the buff, which must be kept well supplied with prepared lamp-black,

pressing the plate hard and evenly against it, and changing the direction frequently, but always ending by polishing in a direction which will cross the picture you wish to obtain upon it; that is, if the plate is to be placed upright in the camera, finish it from side to side, and vice versa. The last polish should be given a short time before the plate is to be used; and any dust which may remain on it should be removed carefully, holding the plate in an inverted position, wth a piece of cotton or a camel's hair pencil, just before the process of iodizing.

Iodizing the Plates.

The best way of securing an even coat of iodine on the plate, is to use the chloride of iodine, diluted with water, two or three drops to an ounce, until it assumes the colour of pale sherry. A little of this mixture being poured into the trough, (described p. 7) sufficient to cover the bottom to about a quarter of an inch in depth; the plate must then be placed in the frame, and carefully put over this solution to expose it to its vapour: in about a minute and a half, or two minutes, according to the temperature of the atmosphere, the plate will be found, on inspection, to have acquired a yellow tint, which will vary from a pale to a rich golden tint, according to the time the plate is allowed to remain in contact with the vapour. This degree of intensity must be varied, to suit the quality of the accelerating liquid employed, as will presently be explained; but care must be taken that the tint on the plate does not pass to the violet, or its sensitiveness will be diminished. The colour of the plate may be inspected, by raising it and turning it towards a white light, replacing it quickly on the trough. When sufficiently iodized, it may be laid aside in the frame with its face downwards, without injury. The same mixture may be used again several times; but it is better to renew it after each time of preparation. Iodine strewed at the bottom of the trough, and covered with fine sand, may replace the chloride mixture, and will last much longer, if carefully covered after use with an air-tight glass or slate cover.

Accelerating Liquids.

There are many varieties of these known by the names of Eau Bromée, Bromide of Iodine, Redman's Sensitive Solution, Hungarian Liquid, etc., etc. The two latter are much used in England,

and will be found to answer well if properly applied. The liquid is diluted with water in the proportion of about one dram to an ounce and a half. A sufficient quantity having been poured into the trough, the plate is placed over it, and allowed to remain until it acquires a red colour, approaching in some cases to violet. The following rules will guide the experimenter in using the different liquids. If bromide of iodine be used as the accelerating agent, the plate should remain over the iodine solution, until it is of a deep yellow tint: and over the bromide, till of a deep rose colour. If Redman's solution, or the Hungarian liquid, a pale yellow and light rose will be found to answer best. As a general rule:—if the yellow colour produced by the iodine be pale, the red should be pale also; if deep, the red must incline to violet. When several plates are to be prepared at the one time, the same solution will serve for all; but it seldom answers to preserve the mixtures for any time; and its use, after keeping, is one great cause of the failures which so annoy amateurs. The bromine contained in these solutions is very subtle, and escapes, leaving little else but iodine remaining, which will, after some little time, give a red colour to the plate, without rendering it sensitive, entirely disappointing the expectations of the operator. The colour of the plate may be examined as before, but care must be taken to replace the plate over the solution for a few seconds, which removes the effect of the light. When the liquid is renewed at each operation, one inspection, at an interval determined by experience, will be generally sufficient. From thirty to sixty seconds, according to temperature, are usually required to produce the effect; in certain states of the atmosphere, a much longer time may be necessary. The plate is now ready for the camera, and may be kept for twelve or eighteen hours, if due care is taken to keep it secure from light or dust. Plates prepared over night are often considered more sensitive than those prepared immediately before using. Frames to carry prepared plates, may be purchased at the opticians. The prepared plate must be transferred to the camera frame with extreme care neither to expose it to light, or rub the surface.

Exposure in the Camera.

The form of camera most suitable for the purpose, has been already described, page 5. The inside should be carefully dusted before using. Having been placed opposite to the object to be copied, and made perfectly steady, a clear and distinct representa-

tion of the object must be obtained upon the ground glass, which must then be withdrawn, and the frame containing the prepared plate introduced in its place. The shutter may then be drawn up, and the plate exposed to the light which passes through the lens. The time of exposure must be decided by observation and experiment; as so much depends on the size and construction of the lens or lenses, and the brightness or dulness of the season. With a good achromatic lens, from five seconds to a minute and a half, will be sufficient in almost every case. In another part will be found some Directions for taking Portraits, Views, etc. which will assist the beginner. The instant the assigned time has elapsed, the shutter must be closed, and the frame may then be withdrawn in readiness for the next operation.

Exposing the Plate to the Vapour of Mercury.

Into the cup at the bottom of the Mercury-box, put four or five ounces of mercury, which must be pure, dry, and free from moisture. It may be occasionally filtered by enclosing it in Chamois leather, and gradually and carefully twisting the leather till the mercury is forced through its pores clean and bright. The vapour of the mercury is raised by the application of a spirit-lamp to the cup which holds the mercury. When a thermometer is attached to the mercury-box, a temperature of about 90 degrees will raise the vapour of the mercury: if the box have no thermometer, the cup may be heated until the mercury is pleasantly warm to the finger. If the mercury cup is removed from the box in order to its being heated, it is well after that operation to wipe the outside, on which a slight steam from the spirit may have settled. The plate, without having been removed from the slide, is then placed over the mercury, where it must remain till the picture is perfectly developed. Its progress may be obseved by the light of a candle through the yellow glass in the front of the box. It generally takes eight to fifteen minutes, or even longer, to perfect the operation; if, however, no outline is visible in about three minutes, either the mercury has not been sufficiently heated, or the picture has been removed too soon from the influence of light in the camera. If the former be the case, the mercury may be again gently heated; but if made too hot, the plate will become covered with small white spots. The details are usually much better developed when the picture has been brought out slowly, and with a moderate degree of heat.

Setting the Picture.

When the picture is sufficiently developed, it may either be set at once, or carefully laid aside until a convenient opportunity occurs. To set Daguerreotype pictures, they must be washed in a suitable vessel, (a preserve pot large enough to contain the plate will answer the purpose,) first in very pure water, and then in a solution of hyposulphite of soda, about fifty grains to the ounce of water, which must be carefully strained, and to which may be added a small quantity of alcohol. The sensitive coating will soon be removed, and the plate should again be washed in pure water, agitating it perpendicularly, until the water runs off in a continuous stream.

Fixing the Image.

The plate being taken from the water, which should never be allowed to dry off, is placed upon a wire stand, adapted to preserve it in a perfectly horizontal position. The gold solution, which may be purchased of the opticians and chemists, or prepared according to the formula given in the Appendix, is poured on the plate, until it is entirely covered, and the flame of a large spirit lamp applied to the under surface, in such a way that every part may be equally heated. In a few moments, the picture will become very clear and bright, when the lamp must be withdrawn, and the plate removed quickly, and again plunged into cold water. The plate is now finally washed, by pouring pure water at a boiling heat over it, holding it as perpendicularly as possible. When the plate is quite clean, it may be dried by blowing gently downwards, and when neatly managed, it will be quite free from spots. The plate may be supported on a stand, as in the washing apparatus, Fig. 12, page 8, or held at the corner with a pair of pliars. The gold solution must be rejected if it should have changed colour, or deposited any precipitate.

The following new mode of fixing and strengthening pictures by oxidation, has been proposed by Mr. Charles G. Page, M. D., Professor of Chemistry, Columbia College, Washington :—

The impression being obtained upon a highly polished plate, and made to receive, by galvanic agency, a very slight deposit of copper from the cupreous cyanide of potassa, (the deposit of copper being just enough to change the colour of the plate in the slightest degree,) is washed very carefully with distilled water, and then heated over a spirit lamp, until the light parts assume a pearly transparent

appearance. The whitening and cleaning up of the picture by this process, is far more beautiful than by the ordinary method of fixation by a deposit of gold. A small portrait fixed in this way, more than a year since, remains unchanged, and continues to be the admiration of persons interested in this art. One remarkable effect produced by this mode of fixing, is the great hardening of the surface, so that the impression is effaced with great difficulty. I have kept a small portrait, thus treated, unsealed and uncovered for over a year, and have frequently exposed it in various ways, and rubbed it smartly with a tuft of cotton, without apparently injuring it; in fact, the oxidised surface is as little liable to change as the surface of gold, and is much harder.

To succeed well in this process, the impression should be carried as far as possible without solarization, the solution of the hyposulphite of soda should be pure, and free from the traces of sulphur. the plate should be carefully washed with distilled water, both before and after it receives the deposit of copper,—in fact, the whole experiment should be neatly performed, to prevent what the French significantly call *taches* upon the plate, when the copper comes to be oxidized.

The formula for the Daguerreotype process, which has now been given, will, we trust, enable the amateur to pursue his experiments with confidence and success. He will probably experience some disappointments, however carefully he may attend to the rules which have been laid down, for there are few among even the ablest experimenters who do not occasionally fail; yet his perseverance will often be rewarded by an excellent picture, when perhaps, he least expects it.

To obviate as much as possible these annoying failures, he should bear in mind the following Cautions, by which he may ofttimes discover the causes which prevent his success:—

Cautions.

1st. Never use the same accelerating liquid more than once or twice, and only at short intervals. It is better to throw it away after preparing such plates as can be prepared at the same time.

2nd. Be sure to replace the plate on the accelerating liquid for a moment or two after having observed the colour, and before putting it in the camera.

3rd. Wipe the lens, and remove all dust and dampness from the camera before using.

4th. Keep the camera and mercury box perfectly free from the vapour of iodine, bromine, etc.

5th. Filter the mercury through a piece of chamois leather, if it should have film or dust collected upon it; the hyposulphite solution used to remove the colour of the plate in setting, must also be filtered before using.

6th. Never use the gold solution after it has changed colour, or thrown down a precipitate. This solution requires filtering occasionally.

7th. Do not make the mercury too hot, it will spot the plate, and spoil the picture.

8th. The direct rays of light must not enter the camera in conjunction with those reflected from the object, the picture will be veiled, and the colour of the plate changed to a thick green.

9th. If the picture appear clouded, it is probably either because the plate has not been thoroughly cleaned, or has absorbed too much Bromine; in the former case, the plate must be cleaned more carefully, in the latter, the accelerating liquid must be changed, or its strength reduced. If it be covered with a white film, the plate has been exposed to light before putting into the camera, or too much light has entered the camera, which may be remedied by using a smaller diapragm. If the whites have become blue, it is overdone, or the mercury has been too much heated; if browned, it is solarized.

COLORED DAGUERREOTYPES.

Daguerreotype portraits are now frequently met with beautifully colored; but the coloring is a process requiring great care and judgment, and many good pictures are spoilt in fruitless experiments. Several different methods of coloring have been proposed. The simplest mode appears to be that of using dry colours ground to a fine powder, and mixed with a little gum, also finely powdered. These are laid on with a fine camel's hair pencil, taking up very little colour at a time, and will adhere to the plate by breathing over it; the picture must be well set. The best colours for this purpose are carmine, rouge, chrome yellow, and ultramarine, by combining which any tint may be obtained.

Mr. Claudet's method is to dip a finely-pointed pencil in spirits of wine, and taking a little of the colour, which must have been pounded with spirits of wine, and again pulverized in a glass mortar, —to apply it upon the plate. This coating must be slight, and may be repeated if necessary; but if too much is put on, it is difficult to remove: the dry colour is applied on this coating, to which it will be found to adhere.

Mr. Chevallier's plan is to trace on the glass which is intended to protect it, the outline of the picture, and then to tint it with the colours used for painting the dissolving views, so as to correspond with the picture underneath. When dry, the tracing may be effaced, the glass fixed, and the picture will then appear through, something in the style of a coloured lithograph.

M. Leotard de Seuze covers the plate with a transparent membrane, or vegetable paper, which he attaches by a solution of gum or size, heated in a water bath; on this membrane he applies colours, mixed with spirits of wine and gum, or with white varnish and alum.*

Mr. Page, whose new method of fixing the Daguerreotype proofs is given page 15, has thrown out the following suggestions on the subject of Coloring:—

As copper assumes various colours, according to the depth of oxidation upon its surface, it follows, that if a thicker coating than the first mentioned can be put upon the plate, without impairing the impression, various colours may be obtained during the fixation. It is impossible for me to give any definite rules concerning this last process; but I will state, in a general way, that my best results were obtained by giving the plate such a coating of copper as to change the tone of the picture, that is, give it a coppery colour, and then heating it over a spirit lamp until it assumes the colour desired. I have now an exposed picture treated in this way at the same time with the two above mentioned, and it remains unchanged. It is of a beautiful green colour, and the impression has not suffered in the least by the oxidation. Should this process be perfected, so as to render it generally available, it will be greatly superior to the present inartistical mode of stippling dry colours upon the impression; for the colour here is due to the surface of the picture itself. For pure landscapes, it has a pleasing effect, and by adopting some of the recent inventions for stopping out the deposit of copper, the green colour may be had wherever desired. In some pictures, a curious variety of colours is obtained, owing to the varying thickness of the deposit of copper, which is governed by the thickness of the deposit of mercury forming the picture. In one instance, a clear and beautiful ruby colour was produced, limited, in a well-defined manner, to the drapery, while all other parts were green.

* These three receipts are condensed from M. Lerebour's excellent Traité de Photographie, from which other valuable suggestions are taken.

PORTRAITS, VIEWS, ETC.

The following hints, gathered from various sources, will be useful to those who have not seen the operation performed by experienced practitioners:—

PORTRAITS.—The sitter should be placed in an easy natural position, in a chair which has a support or rest for the head; an iron rod, with a ring at the end, affixed to the back of the chair, which can be raised or lowered at pleasure, answers well. Portraits are taken with great rapidity in the open air: from five to twenty seconds being usually sufficient, with a good lens, and a clear sky. The direct rays of the sun must be carefully avoided, and it is often desirable to place the sitter under a kind of canopy, or roof of stuff, or glass, which should be blue, that color intercepting fewer of the chemical rays than any other. One side of the model should be rather more illuminated than the other; indeed the position, attitude, arrangement of the dress, etc., all require attention, with a view to artistical effect. If the portrait is taken in a room, the sitter should be placed in front of a door or window, through which there is a strong and uninterrupted light; the time of sitting must of course be extended: a minute to a minute-and-a-half will generally be required. The perfect illumination of the model may be assisted by mirrors, or white linen cloths arranged so as to reflect the light when it is most needed. A short focus lens is best for portraits, as it operates more quickly, but care must be taken to keep the whole of that part of the person appearing in the plate as much in the same plane as possible, otherwise any projecting part, as a hand or leg, will be represented greatly out of proportion. The position of the camera must be determined by circumstances; generally, it should be placed nearly on a level with the face, as the most important point of view. With respect to back grounds, some persons use painted scenes, representing terraces, balconies, gardens, etc.; but they are seldom so correctly managed as to appear well in focus, and certainly rather take off the attention from the main figure. A back ground of an even colour is preferred by many, and may be dark or light according to taste, and the dress or complexion of the model. In the former case, a drab or slate colour suits well; in the latter, an old blanket answers better than any thing else. A table with books, vases of flowers, etc. may be arranged by the side of the sitter, if care be taken that they come

nicely in the focus. Too much white in the dress should carefully be avoided.

VIEWS.—The points from which buildings or views can be taken with the best advantage, vary so greatly, that the operator must be left pretty much to his own discretion, in choosing a position. As a general rule in taking a building, monuments, etc., it is advisable to place the camera at a distance of about twice its greatest dimensions, and, if practicable, at about one-third its height. If the whole of the building or buildings be not in the same plane, select the most important portion to be most clearly defined, or take several views, in each of which certain points are brought out more distinctly. If an old and new building are to be introduced in the same picture, which should, if possible, be avoided, a black screen or handkerchief, or some other opaque body, should be placed over the lens for a moment or two, so as to cut off the rays of light reflected from the brighter portions of the object, the position of which may be previously observed on the ground glass. The same precaution should be taken when the sky is very blue, or strongly illuminated by the sun. The best time for taking views, is undoubtedly the earlier part of the day, though good pictures are often taken in the afternoon. The time required to obtain a good impression, varies so much according to the lens, the weather, the hour, etc., that no certain rules can be given on the subject,—experience will prove the best guide.

ENGRAVINGS, DRAWINGS, etc. may be copied very beautifully with a little care; the whole of the model being in the same plane, there is little difficulty in producing a good effect. The object to be copied must be placed in a good light, taking care to have every part equally illuminated. To secure sharpness, the model is placed in the open daylight, in which case a proof may generally be procured in about fifteen seconds; in the full sunshine, the impression is made almost instantaneously.

MACHINERY, STATUARY, AND ARTICLES OF VERTU, require to be arranged in suitable positions, so that the light may fall upon the object most effectively. The light may be reflected from mirrors, white linen, etc. etc.

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ENGRAVING DAGUERREOTYPE PLATES.

Several plans have been suggested for accomplishing this much desired object; none, however, seem so well adapted as the following, recently patented by M. Claudet, to whom the art is already much indebted. In the specification, the process is explained as follows:—

The process is established upon the following facts, which have come to the knowledge of the inventor:—

1. A mixed acid, composed of water, nitric acid, nitrate of potassa, and common salt, in certain proportions, being poured upon a Daguerrotype picture attacks the pure silver, forming a chloride of that metal, and does not affect the white parts, which are produced by the mercury; but this action does not continue long. Then, by a treatment with ammonia (ammonia containing already chloride of silver in solution is preferable for this operation), the chloride of silver is dissolved, and washed off, and the metal being again in its naked state, or cleansed from the chloride, it can be attacked afresh by the same acid. This acid acts better warm than cold.

2. As all metallic surfaces are soon covered, when exposed to the atmosphere, with greasy or resinous matters, it is necessary, in order that the action of the acid upon the pure silver should have its full effect, for the surface to be perfectly purified; this is effected by the employment of alcohol and caustic potash.

3. When a Daguerrotype picture is submitted to the effect of a boiling concentrated solution of caustic potash, before being attacked by the acid, the state of its surface is so modified that the acid spares or leaves, in the parts which it attacks, a great number of points, which form the grain of the engraving.

4. When the effect of the acid is not sufficient, or in other words, if it has not bitten deep enough, the effect is increased by the following process:—Ink the plate as copper-plate printers do, but with a siccative ink; when the ink is sufficiently dry, polish the white parts of the plate, and gild it by the electrotype process; then wash it with warm caustic potash, and bite in with an acid, which will not attack the gold, but only the metal in those parts which, having been protected by the ink, have not received the coating of gold. By these means the engraving is completed, as by the action of the acid alone it is not generally bitten in deep enough.

5. To protect the plate from the effects of wear, produced by the operation of printing, the following process is employed:—The surface of the plate is covered with a very thin coating of copper, by means of the electrotype process, before submitting it to the operation of printing; and when that pellicle or coating of copper begins to show signs of wear, it must be removed altogether, by plunging the plate in ammonia, or in a weak acid which, by electro chemical action, will dissolve the copper, without affecting the metal under it; the plate is then coppered again, by the same means, and is then ready for producing a further number of impressions. This re-coating operation may be repeated as many times as may be required. The following is the description of the whole process, which is divided into two parts, consisting of a preparatory and finishing process:—

Preparatory Engraving.—For this operation, which is the most delicate, it is necessary to have, 1. A saturated solution of caustic potash. 2. Pure nitric acid at 36° of the areometer of Beaumé (spec. grav. 1·333.) 3. A solution of nitrite of potassa, composed of 100 parts of water and 5 parts of nitrite, by weight. 4. A solution of common salt, composed of water 100 parts, and salt 10 parts, by weight. 5. A weak solution of ammoniacal chloride of silver, with an excess of ammonia. The ammoniacal chloride of silver must be diluted with 15 or 20 parts of pure water. In the description of the process, this solution will be called ammoniacal chloride of silver. 6. A weak solution of ammonia, containing 4 or 5 thousandths of liquid ammonia. This solution will be called ammoniacal water. 7. A weak solution of caustic potash, containing 4 or 5 thousandths of the saturated solution, which will be called alkaline water. 8. A solution composed of water 4 parts, saturated solution of potash 2 parts, alcohol 1 part, all in volume. This solution will be called alcoholized potash. 9. Acidulated water, composed of water 100 parts, and nitric acid 2 parts, in volume. Besides, it is necessary to have three capsulæ or dishes, made of porcelain, large enough to contain the plate, and covered with an air-tight piece of ground plate-glass, and two or three more capsulæ which do not require to be covered; two or three glass funnels, to wash the plate; and two or three glass holders, in the shape of a spoon or shovel, by which the plate is supported when put in and taken out of the solution, without touching it with the fingers.

The Daguerrotype plate is submitted to the engraving process, after having been washed in the hyposulphite of soda, and afterwards in distilled water.

First process for biting in or engraving the plate.—The following solutions must be put in the capsulæ, in sufficient quantity, so as to entirely cover the plate:—1. Acidulated water. 2. Alkaline water. 3. Alcoholized potash, in covered capsulæ. 4. Caustic potash, in covered capsulæ. 5. Distilled water.

The plate being put upon the glass holder or spoon, is plunged in the acidulated water, and agitated during a few seconds, then put into a glass funnel, and washed with distilled water. It is taken again with the glass spoon, and plunged in the capsula containing alcoholized potash. This capsula is covered with its glass cover, and then heated, by means of a spirit-lamp, to about 144° Fahrenheit. The plate must remain in the capsula half an hour, during which the solution is heated now and then, and agitated. During that time, the following acid solution, which will be called *normal acid*, must be prepared; it is composed as follows:—Water 600 parts, nitric acid 45 parts, solution of nitrite of potassa 12 parts, solution of common salt 45 parts. These proportions are in volume. The normal acid must be poured in a capsula, covered with its glass cover, and a sufficient quantity must be kept in the bottle.

When the plate has been immersed in the alcoholized potash during half an hour, it is taken out of the solution by means of the glass holder, and immediately plunged in the alkaline water, and agitated pretty strongly; from thence it is put in distilled water. (A)

This being done, the plate is plunged in the acidulated water, and moved about therein for a few seconds: it is then put into the normal acid. When the plate has been immersed a few seconds in the acid, it is taken out by means of the glass holder, taking care to keep it as much as possible covered with the solution, and it is immediately placed horizontally upon a stand, and as much acid as the plate can hold is poured upon it from the bottle; it is then heated with a spirit-lamp, but without attaining the boiling point. During this operation it is better to stir or move about the acid on the plate by pumping it, and ejecting it again, by means of a pipette or glass syringe; after two or three minutes the acid is thrown away, the plate is put in the glass funnel, and there well washed with water, and afterwards with distilled water. (B)

Then, without letting the plate dry, it is put upon the fingers of the left hand, and with the right hand some ammoniacal chloride of silver, which is moved about the surface by balancing the hand, is poured upon it; the solution is renewed until the chloride, formed by the action of the acid, is dissolved; the plate is then washed by pouring upon it a large quantity of ammoniacal water, and afterwards some distilled water. (C)

Without allowing the plate to dry, it is then put in the caustic potash, and the capsula being placed upon the stand, the potash is heated up to the boiling point; it is then left to cool (D); and beginning again the operations described from A to D, a second biting is obtained; and by repeating again the operations described in A and B, a third biting is produced. The plate is then dried; in this state the black parts of the plate are filled with chloride of silver.

The plate is then polished until the white parts are perfectly pure and bright. This polishing is done with cotton and "ponce" (pumice stone); afterwards, the chloride of silver, filling the black parts, is cleansed by the means described in B and C. The plate is then dried; but before drying, it is well to rub the plate slightly with the finger, in order to take off from the black parts any remains of an insoluble body which generally remain on it. The preparatory engraving is then finished, and the plate has the appearance of a very delicate aquatint engraved plate, not very deeply bitten in.

Nevertheless, if the operation has been well managed, and has been successful, it is deep enough to allow the printing of a considerable number of copies.

Note.—Sometimes, instead of treating the plate with the boiling potash in the capsula, a similar result may be obtained by placing the plate upon the stand, covering it with the solution, and heating it by means of a spirit-lamp, until, by evaporation, the potash becomes in a state of ignited fusion. By this means the grain is finer, but the white parts are more liable to be attacked.

Last operation of biting in.—This operation requires some of the re-agents before named, and also,

1. A siccative ink, made of linseed oil, rendered very siccative by boiling it sufficiently with litharge; it may be thickened with calcined lamp-black.

2. An electrotype apparatus, and some solutions fit to gild and copper the plate.

Means of operating.—The plate must be inked as copper-plate printers do, taking care to clean off the white parts more perfectly than usual; the plate is then to be placed in a room sufficiently warm, until the ink is well dried, which requires more or less time, according to the nature of the oil employed. The drying of the oil may be hastened by heating the plate upon the stand with the lamp, but the slow process is more perfect and certain.

When the ink is well dried, the white parts are cleaned again by polishing the plate with cotton and pounce, or any other polishing powder: a ball of cotton, or any other matter, covered with a thin piece of caoutchouc or skin, can be used for this purpose. When polished, the plate is ready to receive the electro-chemical-coating of gold, which will protect the white parts.

Gilding.—The gilding is obtained by any of the various processes of electrotyping which are known. The only indispensable condition is, that the surface obtained by the precipitation must not be liable to be attacked by any weak acid; a solution answering this purpose is made of ten parts (by weight) of ferrocyanide of potassium, one part of chloride of gold, and 1000 parts of water, used with a galvanic battery. During the gilding the plate must be turned in several positions, in order to regulate the metallic deposit. In some cases the gilding may be made more perfect, if the plate is covered with a thin coating of mercury before being put in the gilding solution.

When the plate is gilded, it must be treated with the boiling caustic potash, by the process already indicated for the preparatory engraving, in order to cleanse it from all the dried oil or ink which fills the hollows. The plate is then washed and dried, and when the oil employed has been thickened with the lamp-black, the surface of the plate is rubbed with crumb of bread, in order to cleanse and take off the black remaining; then, the white parts being covered and protected by a varnish not liable to be attacked, and the black parts being uncovered and clean, the plate can be bitten in by aqua-fortis, according to the ordinary process used by engravers.

This operation must be done upon the stand, and not by immersing the plate in the solution.

Before this last biting-in, if the preparatory engraving has not succeeded well, and the plate still wants a sufficient grain, it can be given by the various processes of aquatint engraving.

Before submitting the plate to the operation of printing, in order to insure an unlimited number of copies, it is necessary, as before stated, to protect it by a slight coating of copper, which is obtained by the electrotype process; otherwise the printing would soon wear the plate. This coating must be kept very thin, lest the fineness of the engraving, and the polish of the white parts, should be destroyed. In this state the plate can be delivered to the printer.

After a certain number of impressions have been obtained, it will be perceived that the coating of copper is worn in some places;

then, this coating must be removed, and a fresh one applied in its place. For this purpose, the plate must be purified and cleansed by warm potash, and plunged in a weak acid composed as follows:—Water, 600 parts; nitric acid, 50 parts; nitrous acid of engravers, 5 parts; all in volume. This acid will dissolve the coating of copper, and the plate being coppered again by the same means as before, may be again submitted to the operation of printing; and as nothing can prevent the success of a repetition of the same operation, any number of impressions may be obtained. The coating of copper can also be removed by caustic ammonia.

The Daguerrotype plate engraved by this process, which constitute the present invention, consist,—

First,—in the discovery and employment of certain properties of a mixture composed of nitric acid, nitrous acid, and hydrochloric acid, in determined or fixed proportions. The two last-mentioned acids may be employed either in a free state, or combined with alkaline or other basis. This mixed acid has the property of biting the pure silver which forms the black parts of the Daguerrotype picture, without attacking the white parts formed by the amalgam of mercury. The result of the action of the biting is to form on the black parts of the picture an insoluble chloride of silver; and this chloride of silver which when formed stops the action of the acid, is dissolved by ammonia, which allows the biting to continue.

Secondly,—in the discovery of certain properties of a warm solution of caustic potash, and in the employment of the said solution, by which the mercury forming the picture is better and deeper amalgamated with the silver under it, so that many imperceptible points of the amalgam are effected in such a manner that the acid has no action upon them.

Thirdly,—in the discovery and employment of a process which produces a grain favourable to the engraving, by which the biting on the plate is rendered deeper. This is effected by filling the parts engraved with a siccative ink, or any other substance, and then gilding the plate by the electrotype process; the gold is not deposited on the parts protected by the ink. When the plate is gilded, the ink is cleansed by the caustic potash, and the plate may be submitted to the effects of an acid which does not attack the coating of gold, but bites only on the silver in the parts already engraved by the first operation.

Fourthly,—in the employment of a process by which the plate is protected from the wear of the printing operation. This is effected by covering the plate before printing with a slight coating of copper

by the electrotype process, and when the coating begins to wear by printing, it is removed by a weak acid, or by ammonia, which dissolves the copper without affecting the silver under it. The plate is coppered again, and after another printing, the same operation is repeated, so that a considerable number of copies may be printed without much injury to the engraving.

M. Daguerre's New Mode of Preparing Plates.

The subjoined account of this process is taken from a letter of M. Daguerre's to Mr. Arago, of the Academie, published in the Comtes Rendus, No. 17, April 22nd, 1844. It presents many difficulties, and has been adopted by very few persons in this country, but as the latest contribution of the inventor of the Daguerreotype, it deserves at least a fair trial.

After stating that the proofs now obtained, though not deficient in purity, leave much to be descried, in general effect and relief, Monsieur Daguerre continues thus :—

It is by superposing on the plate several metals, reducing them to powder by friction, and by acidulating the empty spaces which the molecules leave, that I have been enabled to develop galvanic actions which permit the employment of a much thicker layer of iodide, without having to fear, during the operation of light in the camera-obscura, the influence of the liberated iodine.

The new combination which I employ, and which is composed of several metallic oxides, has the advantage of giving a sensible layer capable of receiving impressions simultaneously by all the degrees of tone; and I thus obtain, in a very short space of time, the representation of objects vividly enlightened with demi-tints, all of which retain, as in nature, their transparency and their relative value.

By adding gold to the metals which I first used, I am enabled to avoid the great difficulty which the use of bromine, as an accelerating substance, presented. It is known, that only very experienced persons could employ bromine with success, and that they were able to obtain the maximum of sensibility only by chance, since it is impossible to determine this point very precisely, and since immediately beyond it the bromine attacks the silver, and is opposed to the formation of the image.

With my new means, the layer of iodine is always saturated with bromine, since the plate may, without inconvenience, be left

exposed to the vapour of this substance for at least half the necessary time; for the application of the layer of gold is opposed to the formation of what is called the veil of bromine. This facility must not, however, be abused; for the layer of gold, being very thin, might be attacked, especially if too much polished. The process which I am about to give may, perhaps, be found rather complicated; but, notwithstanding my desire to simplify it as much as possible, I have been led, on the contrary, by the results of my experiment, to multiply the substances employed, all of which play an important part in the whole process. I regard them all as necessary for obtaining a complete result, which must be the case, since I have only gradually arrived at discovering the properties of these different metals, one of which aids in promptitude, the other in the vigour of the impression, etc.

From the concurrence of these substances, arises a power which neutralises all the unknown effects which so often oppose the formation of the image.

I think, besides, that science and art should not be interrupted by the consideration of a more or less long manipulation; we should be contented to obtain beautiful results at this price, especially when the means of execution are easy.

For the galvanic preparation of the plate does not present any difficulty. The operation is divided into two principal parts: the first, which is the longest, may be made a long time previously, and may be regarded as the completion of the manufacture of the plate. This operation, being once made, serves indefinitely; and, without recommencing it, a great number of impressions may be made on the same plate.

Preparation of the New Substances.

Aqueous Solution of Bichloride of Mercury.—5 decigrammes of bichloride of mercury in 700 grammes of distilled water.

Solution of Cyanide of Mercury.—A flask of distilled water is saturated with cyanide of mercury, and a certain quantity is decanted, which is diluted by an equal quantity of distilled water.

Acidulated White Oil of Petroleum.—This oil is acidulated by mixing with it one-tenth of pure nitric acid, leaving it at least forty-eight hours, occasionally agitating the flask. The oil, which is acidulated, and which then powerfully reddens litmus paper, is decanted. It is also a little coloured, but remains very limpid.

Solution of Chloride of Gold and Platinum.—In order not to

multiply the solutions, I take the ordinary chloride of gold, used for fixing the impressions, and which is composed of 1 gramme of chloride of gold, and 4 grammes of hyphosulphite of soda, to a quart of distilled water.

With respect to chloride of platinum, 2½ decigrammes must be dissolved in three quarts of distilled water; these two solutions are mixed in equal quantities.

Modus Operandi.

First Preparation of the Plate.

Note.—For the sake of brevity in the following description, I will abridge the name of each substance. Thus, I will say, to designate the aqueous solution of bichloride of mercury, sublimate; for the solution of cyanide of mercury, cyanide; for the acidulated oil of petroleum, oil; for the solution of chloride of gold and platinum, gold and platinum; and for the oxide of iron, rouge only.

The plate is first polished with sublimate and tripoli, and afterwards with rouge, until a beautiful black is arrived at. Then, the plate is layed on the horizontal plate, and the solution of cyanide is poured on it and heated over a lamp, as in fixing an impression with chloride of gold. The mercury is deposited, and forms a whitish layer. The plate is allowed to cool a little, and, after having poured off the liquid, it is dried by rubbing with cotton and sprinkling it with rouge.

It is now necessary to polish the whitish layer deposited by the mercury. With a piece of cotton steeped in oil and rouge, this layer is rubbed until it becomes of a fine black. In the last place, it may be rubbed very strongly, but with cotton alone, in order to render the acidulated layer as thin as possible.

The plate is afterwards placed on the horizontal plane, and the solution of gold and platinum is poured on. It is heated in the ordinary manner; it is then allowed to cool, the liquid is poured off, and it is dried by gentle friction with cotton and rouge.

This operation must be performed with care, especially when the impression is not immediately continued; for, otherwise, some lines of liquid would be left on the plate, which it is difficult to get rid of. After this last friction, the plates should be only dried, and not polished.

This concludes the first preparation of the plate, which may be made a long time previously.

Second Preparation.

Note.—I do not think it fit to allow a longer interval than twelve hours to intervene between this operation and iodizing the plate.

We left the plate with a deposit of gold and platinum. In order to polish the metallic layer, the plate is rubbed with a piece of cotton, and oil and rouge, until it again becomes black ; and then with alcohol and cotton only, in order to remove this layer of rouge as much as possible.

The plate is then rubbed very strongly, and passing several times over the same places, with cotton impregnated with cyanide. As this layer dries very promptly, it might leave on the plate traces of inequality ; in order to avoid this, the cyanide must be again passed over it, and, while the plate is still moist, we quickly rub over the whole surface of the plate with cotton imbibed with a little oil, thus mixing these two substances ; then, with a piece of dry cotton, we rub in order to unite, and at the same time, to dry the plate, taking care to remove from the cotton the parts which are moistened with cyanide and oil. Finally, as the cotton still leaves traces, the plate is likewise sprinkled with a little rouge, which is removed by gently rubbing.

Afterwards, the plate is again rubbed with cotton impregnated with oil, only in such a manner as to make the burnish of the metal return ; it is then sprinkled with rouge, and then very gently rubbed round, in such a manner as to remove all the rouge, which carries with it the superabundance of the acidulated layer.

Finally, it is strongly rubbed with a rather firm pledget of cotton, in order to give the best polish.

It is not necessary often to renew the pledgets of cotton imbibed with oil and rouge ; they must only be kept free from dust. I have said above, that the first preparation of the plate may serve indefinitely ; but it will be comprehended, that the second must be modified, according to whether we operate on a plate which has received a fixed or an unfixed impression.

On the Fixed Impression.

The stains left by the washing-water, must be removed with rouge and water, slightly acidulated with nitric acid (at 36° F. at this season [April?] and less in summer.)

Afterwards, the plate must be polished with oil and rouge, in order to remove all traces of the image.

The operation is then continued, as I have just described, for the second preparation of the new plate, and beginning with the employment of alcohol.

On the Unfixed Impression (but whose sensible layer has been removed in the ordinary manner.)

First, the plate must be rubbed with alcohol and rouge, in order to remove the traces of oil which serve for receiving the foregoing impression.

We afterwards proceed, as indicated above, for the new plate, beginning with the employment of alcohol.

Observations.

On Iodizing.—The colour of the impression depends on the tint given to the metallic iodide; it may, therefore, be varied at will. However, I have found the violet rose colour most suitable.

For transmitting the iodine to the plate, the sheet of cardboard may be replaced by an earthenware plate, deprived of enamel. The iodine transmitted by this means is not decomposed; it is useless, I may even say injurious, to heat the plate before exposing it to the vapour of iodine.

Washing with Hyposulphite of Soda.—In order to remove the sensible layer, the solution of hyposulphite of soda must not be too strong, because it destroys the sharpness of the impression. Sixty grammes of hyposulphite are sufficient for 1 quart of distilled water.

APPENDIX.

We subjoin the formula for making a few of the solutions used in the Daguerreotype process; but we must caution those who may be ignorant of Chemistry, that some of the substances used, are deleterious and corrosive, and that great care should be taken that

they do not touch the person, dress, or surrounding objects. A drop of Bromine, for example, accidentally thrown into the eye might easily destroy the sight.

Chloride of Iodine.

The Chlorine is procured by putting pure oxide of manganese, broken into small pieces in a glass retort, and pouring upon it some hydro-chloric (muriatic) acid. The retort communicates by a bent tube with a small bottle containing iodine, which it promptly liquefies. When the resulting liquid becomes a bright red, the operation is complete. The Chloride of Iodine should be preserved in a bottle well stopped, a little white wax round the stopper will prevent its adhering to the neck of the bottle. In conducting this operation, precaution must be taken that the Chlorine does not escape; this gas being highly deleterious.

Eau Bromee.

Add an excess of Bromine to pure water* in a bottle, shaking it well for some minutes. To one part of this solution, add forty parts water, and the mixture, of a bright yellow, is ready for use.

Bromide of Iodine.

In a bottle which holds about three ounces, put 30 to 40 drops of Bromine,—the quantity is not very important. Add Iodine, grain by grain, till the Bromine is saturated. The Iodine which does not dissolve, may remain in the bottle. To one part of Bromide of Iodine, add 200 parts water, and it is ready for use.

Gilding Solution.

The receipt for this solution, as given by M. Fizeau, the inventor of this method of fixing, is as follows:—

Dissolve one part of Chloride Gold in 800 parts of water, and four parts hyposulphite soda in 200 parts water,—pour the solution of gold into that of soda, by little and little, shaking it all the while, the mixture at first slightly yellow, soon becomes perfectly limpid. This mixture may be bought ready prepared of the Opticians.

* If you are nof sure of the purity of the water, add a few drops of nitric acid.

COMPARISON OF FRENCH AND ENGLISH MEASURES.

Measures of Weight.

	English Grains.	Avord. Weight.
Decigramme	1.5433 ..	
Gramme	15.4330 ..	
Decigramme	154.3300 ..	0.022
Hectogramme	1543.330 ..	0.220
Kilogramme	15433.0000 .	2.204

MEASURES OF CAPACITY.

	IMPERIAL. Galls.	Pints.
Litre	0 ..	1.76377
Decalitre	2 ..	1.4464

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Ditto. Ditto. with compound set of achromatic lens, (See Fig. 5) 6 6 0

This apparatus has the advantage of serving with all sorts of object glasses, whether simple or compound, and for all sizes of plates: its construction is very simple, and not likely to get out of order.

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Ditto. Ditto. with double combination of achromatic lenses 14 0 0

Small Photographic Cameras, with sliding tube, and Periscopic or Plano convex lenses, adapted either

for the Daguerreotype, Calotype, or Energiatype processes		1	1	0
Do. Do.	with Achromatic Lens	1	5	0
„	with rackwork adjustment fig. 11	1	15	0
„	with calotype chemicals and apparatus	2	10	0
„	with Daguerreotype apparatus and materials, complete in case	5	5	0
Second size do.	with achromatic lens, and sliding tube	1	15	0
„ „	with rackwork adjustment	2	2	0
„ „	with calotype chemicals and apparatus	3	16	0
„ „	with Daguerreotype apparatus, and materials complete in case	6	10	0
Lerebour's Parisian Apparatus, with the latest improvements.				
Cundell's Photographic Cameras, as described in the Philosophical Magazine, with double miniscus lenses		3	3	0
Voitglander's Double Combination of Achromatic Lenses, 3 in. diameter, mounted in brass cells, and tube with rack-work adjustment (Fig. 5)		20	0	0
Ditto. Ditto.	2 inches diameter.	10	10	0
Ditto Ditto.	1¾ — diameter.	6	6	0
Double Combination of achromatic lenses of very superior English manufacture, of corresponding curvature to Voitglander's, mounted in brass front, with rackwork adjustment, 3 in. diameter				
Ditto. Ditto.	2 in. diameter	4	4	0
Ditto. Ditto.	1½ in. diameter	3	3	0
Ditto. Ditto.	1 in. diameter	2	10	0

The advantage gained by using the double combination of achromatic lenses over the single arrangement is, that they are far more rapid in their operation, and give a much sharper picture.

Achromatic lenses, 1 inch diameter, 4 inch focus, and upwards		0	6	0
Do.	1½ inch diameter, 5 inch focus,	0	8	0
Do.	1¾ „ 6 „	0	10	6
Do.	2 „ 6 „	0	14	0

Parallel Mirrors mounted in brass frames, to attach to the front of the Camera, for reversing the pictures, (Fig. 5. D)

Prisms for Ditto. Ditto.

Plano Convex, Periscopic. and every description of Lens required in Photographic Experiments.

Brass Camera Fronts, with rackwork adjustment for 1-inch lens, 11s.; 1¼-inch lens, 12s.; 1½-inch lens, 14s.; 1¾-inch lens, 15s.; 2-inch lens, 18s.

Brass Camera Fronts, with sliding tube for 1-inch lens, 6s.; 1¼-inch lens, 7s.; 1½-inch lens, 9s.; 1¾-inch lens, 10s.; 2-inch lens, 12s.			
Brass Camera Fronts, with revolving diaphragm, on which are apertures of different diameters for regulating the intensity of the light, according to the nature of the picture, 1¼ in.....	0	7	0
Ditto. Ditto. 1½ in.....	0	9	0
Ditto. Ditto. 1¾ in.....	0	10	6
Ditto. Ditto. 2 in.....	0	15	0
Mercury Boxes for small Cameras	0	13	0
Ditto. Ditto. ..... 15s.	0	18	0
Ditto. Ditto. best construction, with cast iron cistern, sliding front and legs, and coloured glass windows for viewing the developement of the picture	1	4	0
Ditto. Ditto. with Thermometer, ... from	1	11	0
Plate Boxes to contain a supply of plates in mahogany or walnut wood, (Fig. 10.)			
Ditto. for 2½ × 2 in plates.	0	4	0
Ditto. for 2¾ × 3¼ „	0	5	0
Ditto. for 4 × 3 „	0	5	6
Ditto. in Japanned Metal.			
Ditto. for 2½ × 2 in. plates.	0	1	9
Ditto. for 3¼ × 2¾ „	0	2	6
Ditto. for 4 × 3 „	0	3	0
Iodizing and Bromine Pans made of hard glazed porcelain, with air-tight slate covers ..... each	0	2	0
Ditto. Ditto fitted in mahogany or walnut cases, with three frames for holding the various sized plates		10	0
Dark Coloured Glasses for the Bromine Solutions, or Chloride of Iodine,..... from	0	4	0
Iodine Boxes of various constructions.			
Earthenware Washing Tray and Stand (Fig. 12.).....	0	3	6
Do. in Copper and Glass			
Prepared Velvet Buffs for polishing, (Fig. 9.).....each	0	2	9
Polishing Block for holding the plates during the polishing process (Fig. 8.)	0	3	6
Plate Holders .....from	0	1	6
Glass Spirit Lamps .....each 2s. 3s. and	0	4	0
Brass Ditto. (Fig 11.) .....each	0	3	6
Brass Stands for supporting plates, (Fig. 11) 2s. 6d. 3s. 6d.	0	5	0
Ditto. with levelling screws..... from	0	5	6
Folding Tripod Staff with brass mountings, and ball, and socket-joints, and screw-plate to attach to Camera, (Fig. 13. C)			
Portable Folding Tripod Stand, with table to fix on top, (Fig. 13. B)..... from	1	1	0
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French Pattern Double Folding Tripod Stand, with table, etc., (Fig. 13. A.)			
This Instrument is exceedingly firm and steady.			

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Finely Carded Cotton Wool .....per ounce 0 0 4
Apparatus for the Preparation of Chlorine Gas..... 0 2 6
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Pressure Frame and glass, with sliding lid, for obtaining positive Photographs, or copying Engravings, Lace, Leaves, etc. etc. ..... from 0 5 0
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3¼	„	2¾	„	„	0	18	0
4	„	3	„	„	1	7	0
5	„	4	„	„			

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If less than a dozen are taken, the prices will be rather higher.

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CHEMICAL PREPARATIONS.

Iodine	per oz.		
Do. pure	„		
Do. Tincture	„		
Do. Chloride	„		
Do, Bromide	„		
Bromine, pure	„	0	4 6
Distilled Mercury	per lb.		
Hyposulphite Soda	per oz.	0	0 6
Chloride Gold Solution	2s. 6d. and „	0	5 0
Chloride Gold Chryst.			
Nitric acid, pure	„	0	0 4
Prepared Tripoli	„	0	0 6
——— Rouge	„	0	0 6
——— Emery	„	0	0 6
——— Lamp Black	„	0	1 0
Rulman's Sensitive Solution	per bottle	0	2 6
Hyposulphite Gold Solution	per oz.	0	0 3
Hyposulphite Gold Chryst.			
Improved Solution of Gold for fixing Daguerreotye Images	per bottle	0	1 6
Pure Gallic Acid	per oz.	0	10 0
„ Succinic Acid	„	0	10 0
Bromide Potassium	„	0	5 0
Pure Chloride Lime	„	0	0 6
Strong Solution Ammonia	„	0	0 4
Proto Sulphate Iron	„	0	0 4
Gum Arabic	„	0	0 6
Oil of Cloves	„	0	4 0
„ of Cassia	„	0	5 0
Hyposulphite Soda	„	0	0 6
Pure Cyanide Potassium	1s. or „	0	2 0
Iodide Potassium	„	0	3 0
Chloride Potassa	„	0	0 6
Alcohol	per pint	0	3 6

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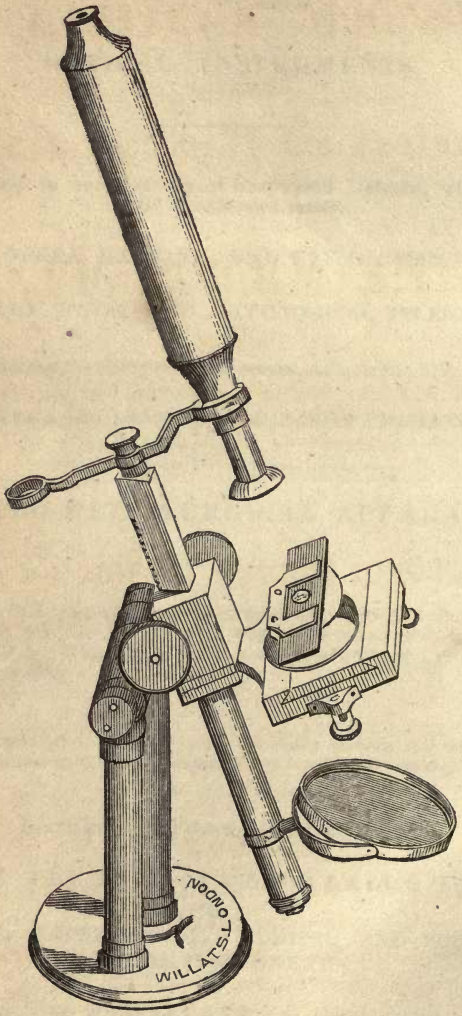
LONDON
WILLATS

MICROSCOPIC MANIPULATION;

CONTAINING

THE THEORY AND PLAIN INSTRUCTIONS

FOR THE USE OF

THE MICROSCOPE,

INCLUDING

THE BEST METHODS FOR THE MOUNTING OF OBJECTS, AND A REVIEW OF THE IMPORTANT DISCOVERIES EFFECTED BY THIS INSTRUMENT.

BY

GEORGE THOMAS FISHER, JUN.

AUTHOR OF "PHOTOGENIC MANIPULATION," "A TREATISE ON MEDICAL ELECTRICITY," ETC.

ILLUSTRATED BY WOOD-CUTS.

LONDON:

THOMAS & RICHARD WILLATS, OPTICIANS,

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AND ALL BOOKSELLERS.

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TO

JOHN P. GASSIOT, ESQUIRE,

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This little Work

IS MOST RESPECTFULLY DEDICATED,

AS A HUMBLE THOUGH GRATEFUL AND SINCERE ACKNOWLEDGMENT FOR MANY ACTS OF KINDNESS RECEIVED AT HIS HANDS,

BY HIS OBEDIENT SERVANT,

GEORGE THOMAS FISHER.

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INTRODUCTORY REMARKS.

1. Of all philosophical instruments there are certainly none which are more interesting, or which present greater claims to our admiration than the Microscope.* Wherever we turn, within the precincts of our own homes—in meadow or moorland, hill or forest, by the lone seashore or amidst crumbling ruins—fresh objects of interest are constantly to be found;—plants and animals, unknown to our unaided vision, with minute organs perfectly adapted to their necessities; with appetites as keen, enjoyments as perfect as our own. In the purest waters, as well as in thick, acid, and saline fluids, of the most indifferent climates,—in springs, rivers, lakes, and seas,—often in the internal humidity of living plants and animals,—even in great numbers in the living human body—nay, probably carried about in the aqueous vapours and dust of the whole atmosphere—there is a world of minute, living, organised beings, imperceptible to the ordinary senses of man. In the daily course of life, this immense mysterious kingdom of diminutive living beings is unnoticed and disregarded; but it appears great and astonishing beyond all expectation, to the retired observer, who views it by the aid of the microscope. In every drop of standing water, he very frequently, though not always, discovers by its aid rapidly moving bodies, from 1-96 to less than 1-2000 of a line in diameter, which are often so crowded together that the intervals between them are less than their diameter. If we assume the size of the drop of water to be one cubic line, and the intervals, though they are often smaller, to be equal to the diameter of the bodies, we may easily calculate, without exaggeration, that such a drop is inhabited by, from one hundred thousand to one thousand millions of such animalculæ; in fact, we must come to the conclusion, that a single drop of water, under such circumstances, contains more inhabitants than there are individuals of the human race upon our planet. If further, we reflect on the amount of life in a

* From μικρος *small*, and σκοπεω *to observe*.

large quantity of water, in a ditch or pond, for example; or if we calculate, that according to many observers of the sea, and especially of its phosphorescence, vast tracts of the ocean periodically exhibit a similar development of masses of microscopic organised bodies; even if we assume much greater intervals; we have numbers and relations of creatures living on the earth, invisible to the naked eye, at the very thought of which the mind is lost in wonder and admiration. It is the microscope alone, which has enabled close observers of nature to unveil such a world of her diminutive creation, just as it was the art of making good telescopes which first opened to their view the boundless variety and all the wonders of the starry firmament.

2. But it is not here that the utility or interest of the microscope ceases. To the botanist, the zoologist, the geologist, and the physiologist it is equally valuable, equally indispensable. By its aid may we examine the minute structure of the organs and tissues of which plants and animals are made up,—by it discover the links which bind the vegetable to the animal kingdom,—by it are we enabled to ascertain the nature of the vegetation which decked the earth, long ere man "moved, and breathed, and had his being;" and by it may the anatomist discover the structure in health, and the derangement from disease of the various organs of the body.

More recently the microscope has been brought to bear upon the fossil animals, which are constantly being discovered in all parts of the world. By a careful examination of sections of teeth and other bones, the classification of the animals to which they belonged, as made by geologists from other data, has in most instances been proved to be correct. "In the hands of an Owen and a Mantell, the microscope becomes an instrument of magic power; by means of which, from the inspection of a bone or a tooth, the colossal reptiles of the ancient earth are revived in all the reality of life and being, and the early formations of the earth peopled with their former inhabitants again." In medico legal enquiries, the microscope again comes to our aid in detecting the murderer, and rendering him back the poison grain for grain. Blood and other organic stains are by its means readily detected when all other methods have failed.

PLAIN INSTRUCTIONS

FOR

THE USE OF THE MICROSCOPE.

Chapter I.

HISTORY OF THE MICROSCOPE.

3. The History of the Microscope, like that of many other valuable inventions, has been veiled in considerable obscurity by the lapse of time. It seems pretty certain that the ancients were not unacquainted with the microscope, in one at least of those forms of which we shall have to speak, if we are to give credence to a passage in Seneca. "Letters," says he, "though minute and obscure, appear larger and clearer through a glass bubble filled with water." Amongst the moderns, (for during the middle ages it appears to have been entirely lost,) the honor of its discovery has been claimed by many individuals. By Huygens, the celebrated Dutch mathematician, its invention is attributed to one of his countrymen, named Drebell. Microscopes were constructed by him in the year 1521, that is to say shortly after the invention of the telescope. It is asserted by Borrelli, that Jansen, the reputed contriver of the telescope, was its inventor, and that he presented some such instruments to Prince Maurice, and Albert, Archduke of Austria. These instruments were six feet in length, and consisted of a tube of gilt copper, supported by thin brass pillars in the shape of dolphins, on a base of ebony, which was adapted to hold the objects to be examined. Of the internal construction of this microscope we have no account, though there is reason to believe that it was nothing more than a telescope converted into a microscope. Viviani,

an Italian mathematician, also expressly informs us, in his Life of Galileo, that this great man was led to the construction of the microscope from that of the telescope; and in the year 1612 he actually sent a microscope to Sigismund, King of Poland. In the year 1618, Fontana, a Neapolitan, made a microscope of two double convex lenses, and wrote an account of it in a work which he published in 1646.

For a long period, however, curious as the fact may now appear, the single microscope was that generally in use, and the compound instrument was considered as a mere philosophical toy, owing to the distance which the light had to traverse, and the consequent increase of the chromatic and spherical aberrations. Indeed so impossible did it appear to overcome this great difficulty, that within thirty years of the present period, philosophers of no less eminence than M. Biot and Dr. Wollaston predicted, that the compound would never rival the simple microscope, and that the idea of rendering its object-glass achromatic was hopeless. Nor can these opinions be wondered at, when we consider how many years the achromatic telescope had existed without any attempt to apply its principles to the compound microscope. When we consider the smallness of the pencil required by the microscope, and the enormous increase of difficulty attending every enlargement of the pencil; when we consider further, that these difficulties had to be contended with, and removed, by operations on portions of glass so small that they were themselves almost microscopic objects, we shall not be surprised, that even a cautious philosopher and able manipulator, like Dr. Wollaston, should prescribe limits to its improvement.

4. Fortunately, however, for science, and especially for the departments of animal and vegetable physiology, these predictions have been shown to be unfounded. The last fifteen years have sufficed to elevate the compound microscope from the condition we have described, to that of being the most important instrument ever bestowed by art upon the investigator of nature. It now holds a very high rank amongst philosophical instruments; while the transcendent beauties of form, colour, and organization which it reveals to us, in the minute works of nature, render it subservient to the most delightful and instructive pursuits. To these claims on our attention it appears likely to add a

third of still higher importance. The microscopic examination of the blood and other human organic matter, will, in all probability, more than ever it has yet done, afford satisfactory and conclusive evidence regarding the nature and seat of disease, than any hitherto appealed to; and will, of consequence, lead to similar certainty in the choice and application of remedies.

5. Soon after the year 1820, a series of experiments was begun in France, by M. Selligues, which were followed up by Frauenhofer, at Munich, by Amici, at Modena, by Chevalier, at Paris, and by the late Mr. Tulley, of London. In 1824, the last-named artist, without knowing what had been done on the continent, made an attempt to construct an achromatic object-glass for a compound microscope, and produced one of 9-10ths of an inch focal length, composed of three lenses, and transmitting a pencil of eighteen degrees. This was the first that had been made in England. While these practical investigations were in progress, the subject of achromatism engaged the attention of some of the most profound mathematicians in England. Sir John Herschel, Professor Airy, Professor Barlow, Mr. Coddington, and others, contributed largely to the theoretical examination of the subject; and though the results of their labours were not immediately applicable to the microscope, they essentially promoted its improvement. Between this period and the year 1829, Mr. Joseph Jackson Lister had directed his attention more particularly to this subject, and he was led to the discovery of certain properties in achromatic combinations which had been before unobserved. A paper on the subject was sent by him to, and published by, the Royal Society.* To the practical optician the investigations and results of Mr. Lister proved to be of the highest value; and the progress of improvement was in consequence extremely rapid, and since that period every year has brought this instrument nearer to perfection.

6. It would be foreign to the intentions of this work, to enter into any lengthened details of the optical principles involved in the construction of the microscope, or to trace out the various steps by which the chromatic and spherical aberration, which rendered the early instruments useless, have now been overcome. To the optician and the

* Philosophical Transactions, 1829.

actual manufacturer of the microscope alone would this information be of interest; and as this little Manual is intended rather for the use of the amateur and general reader, and has been written with the view of conveying a knowledge of the manipulation of the instrument, and the method of preparing and classifying objects for it, we shall content ourselves with a brief enumeration only of the optical principles on which it is constructed, dwelling more largely upon its use, and its wondrous revelations."*

Chapter II.

CONSTRUCTION OF MICROSCOPES.

7. The forms of microscopes are very numerous, but they may all be included in two distinct classes, however much they may vary as to their external appearances, viz. :—Single Microscopes, in which the object itself is magnified, whether by a single lens, or a combination of lenses; and Compound Microscopes, in which a magnified image of the object, not the object itself, is magnified.

8. To comprehend how it is that the lenses, which are used in the formation of all descriptions of microscopes, increase the size of objects, or magnify them, as it is termed, the reader must clearly understand what is meant by the apparent magnitude of objects. If a small coin be placed at the distance of a hundred yards from us, it will be scarcely perceptible; and its apparent magnitude, or the angle under which it is seen, is said to be then extremely small. At the distance of twenty or thirty yards we should just perceive that it was a round body, and that its apparent magnitude had increased; at the distance of three yards, we should begin to trace the effigy and inscription upon

* To those who may be desirous of studying this question more in detail, we would recommend for consultation, *Brewster's Treatise on Optics;* Article *Microscope, in the Penny Cyclopædia,* and the same Article in the 'Edinburgh Cyclopædeia,' and the 'Encyclopædeia Britannica.'

it; and at the distance of six or eight inches, its apparent magnitude is so great, that it appears to cover a distant object fifty or one hundred times its size. By thus bringing the coin nearer the eye, we have actually magnified it, or made it apparently larger, though its size remains the same. Again, as a further example of this: if we look at two men of the same height, the one 200 feet, the other 100 feet from us, the former will appear only half the height of the latter, or the angle which the latter subtends to the eye of the observer will be twice that of the former. Hence it becomes evident that the nearer we can bring an object to the eye the larger will it appear.

9. But let us suppose that the object be distant from us twenty feet, and let a convex lens, whose focal length is five feet, be placed half way between it and the eye, that is to say ten feet from each, then it is plain that the image of the object, as formed by the refracting power of the lens, will be exactly of the same size as the object, and consequently it is not directly magnified by the lens; but as the image is brought so near to us that the eye can view it at the distance of six inches, its apparent magnitude is increased in the proportion of six inches to twenty feet, or as one to forty,—that is forty times. It is, in fact, magnified forty times, merely by bringing an image of it nearer to the eye.

10. But if we have to examine a very minute object, and in order to render its parts distinguishable we bring it very near to the eye, within an inch or two, for example, it will become very indistinct and confused. This effect is produced by the great divergence of the rays of light from the object, and the power of the chrystalline lens of the eye not being sufficient to collect the rays, whereby an image of the object may be formed on the retina, at the proper distance on the back of the eye. Now if we employ a convex lens, and place it between the object and the eye, the former being in the focus of the glass, the diverging rays from the object will be refracted and rendered parallel by the lens, and thus we shall obtain a distinct and near view of the object. If we place the lens close to the eye and the object, in such a way that the rays which flow from it may receive that precise degree of divergency which they had when the object is placed six inches from the eye, the nearest distance at which we see minute objects distinctly, if the dis-

tance be an inch, the object will have its apparent magnitude six times greater than when it is seen at the distance of six inches without the lens. It is therefore said to be magnified six times by the lens. This lens therefore is a single microscope, and the magnifying power of such microscopes may be always found by dividing six inches by the focal distance of the lens. A lens, for example the tenth of an inch in focal length, will magnify 60 times; and one the hundredth of an inch, 600 times.

11. SINGLE MICROSCOPES.—Single microscopes may consist, as we have already said, of one or more lenses, but in all cases it is the object itself which is magnified. The simplest form of single microscope is that which consists of a single lens or spherical globule, fitted up so that it may be conveniently held to the eye, the object being at the focus of the lens. A common hollow globe of glass an inch in diameter, and filled with water, is of itself a single microscope; so would be a drop of water, placed upon a hole drilled in a thin piece of brass. A lens is, of course, far preferable to either of these contrivances. For a variety of purposes, a single lens is an extremely useful instrument, and they are usually mounted by opticians in a number of ways for portability and convenience. Figs. 1 and 2 represent forms of single microscopic lenses, mounted in such a manner as to be folded up and carried in the pocket.

Fig. 1.

Fig. 2.

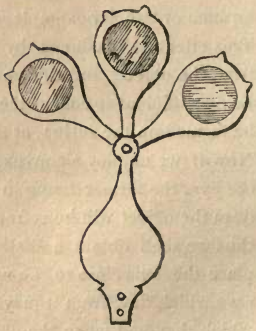


Fig. 3.

Fig. 3 is a useful combination of three lenses, mounted in a case of a convenient size for the pocket. By varying the arrangement of the lenses, or by taking each separately, it affords many degrees of magnifying power.

Fig. 4 and 5 represent other forms of microscopic lens, much in use for the examination of linen cloth, and for ascertaining the number of threads in a given space.

Fig. 4.

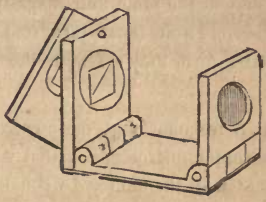


Fig. 5.

12. STANHOPE LENS.—But, perhaps, the most powerful of these simple lenses is that invented by Lord Stanhope. It is a double convex lens, the end however which is nearest to the eye being ground more convex than the other, in the proportion of three to five. It is set in a metal cylinder, the length of which is the exact focus of the lens, and thus it possesses great advantages over every other form of common lens. By it all difficulty of retaining the instrument to the exact focus, and the loss of light and small field are obviated. The object to be examined has only to be placed on the less convex end of the lens, or to be brought in contact with it, when the advantage of great magnifying power and a field of nearly five inches are obtained. Its general form is represented in the annexed figure.

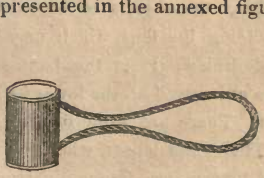


Fig. 6.

So powerful are these lenses that many interesting objects may be

distinctly seen by them,—such as animalcules in water, mites in cheese, hairs of animals, down of moths, etc.; and the process of chrystallization may also be conveniently watched with them.

13. Coddington's Lens.—Of these simple lenses, the best unquestionably for viewing opaque objects, chrystals, etc. is that which has, from its inventor, been denominated the Coddington lens. It is a small sphere of glass, with its equatorial parts ground away that it may at the same time magnify and yet be corrected for spherical aberration. These lenses are sold by all optical instrument makers. In external form they resemble the Stanhope lens.

14. A frequent and most convenient form of simple microscope, is that which is represented in the annexed woodcut, and which has the advantage of great portability. From the arrangement of the mountings to suit the nature of the objects to be examined, these microscopes often derive their name, though the principle of all of them is similar—as botanical, mineralogical, anatomical, natural history, aquatic microscopes. A is a piece of thick brass, with a channel cut along it to enable B to slide along it. The arm A being jointed, is capable of lying flat when out of use, or can be altered to suit any other convenient position. B is a brass pillar terminated by a pair of nippers C, for holding the objects to be examined; D is a brass socket and screw holding the lens, which may be thus changed for another, if it be desirable; E is the handle to hold the instrument, which may be unscrewed at the lower half, and thus rendered exceedingly compact. There are often in the socket D two lenses, one at each side. These two lenses, when low power is wanted, as in the inspection of flowers, are frequently two plano-convex lenses with their plain sides turned towards the eye. The advantages of this combination are, an increase of field and the diminution of

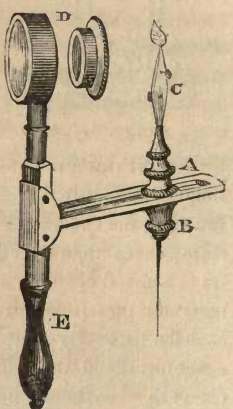


Fig. 7.

aberration. The focal distances of the lenses mounted in the single microscopes, are usually 1½-inch, 1-inch, ½, ¼, 1-16th, 1-20th of an inch.

15. But the most perfect form of single microscope is that which is represented in the annexed diagram, and which, as far as its power extends, is suitable for the examination of any kind of object. It consists of a circular brass stand, capable of being fixed in every possible inclination by the ball C attached to the clamp B, by which the whole may be firmly fixed to a board or table; the circular mirror D working in the arm M is attached to the tube X in the usual way. The whole slides upon the stem, that it may be placed nearer to or farther from the object, according to the intensity of the light required for the various objects under examination. The back of this reflector is flat and polished, so that a monochromatic light reflected from the brass may be employed when necessary.

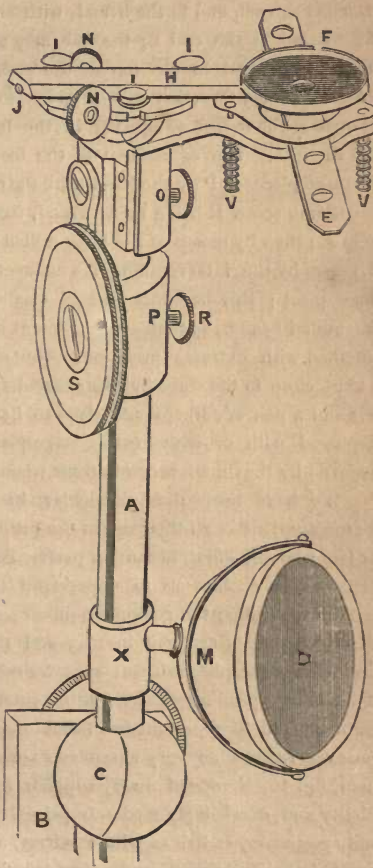


Fig. 8.

The lenses are mounted in cells as shown at F, and are screwed into the dovetail bar H, sliding between three stout pins I I I, the nearest one having a strong pin on the under side which keeps the bar in close contact with the other two without any shake. The bar is moved across the object by either of the nuts N N, which instead of having a pinion, as usual, have a spring wound round their axis attached at each end to the bar H, with an adjusting screw to regulate the tension at the end J; the bar may also be turned round on the central pin fitted in the top of the stem A, and thus a traversing motion in every direction may be given to the bar and lens, without disturbing the object or altering in the least the distance between it and the lens. The adjustment of the focus is first made by sliding the stage pieces O P by the hand until the object is seen nearly distinct, the thumb screw R being then turned, fixes the lower piece P to the stem A; then by means of the large milled head S, the final adjustment is made by the intervention of a connecting bar T attached to the stage piece; this bar works on an elastic eccentric movement under the milled head S, so that an adjustment of any small quantity can be obtained with extreme precision. The slider containing the object is kept close to the stage by two heliacal springs V V. A condensing lens and a pair of forceps are made to fit in the piece O, and can be employed with or without the stage-plate, which may be entirely removed by the thumb-screw in front when necessary.

We have been thus particular in the description of single microscopes, although their use in the present day is extremely limited, for two reasons,—first, because a perfect comprehension of that instrument better enables us to understand the principles of the more perfect apparatus, the compound microscope; and, secondly, because such instruments are still in use, and this Manual would therefore have been incomplete without such a description. For certain kinds of botanical specimens, the single microscopes are exceedingly useful. Figures 9 and 10 represent two forms of botanical microscopes, which however require no very extended explanation. The latter instrument, fig. 10, is indeed a very superior apparatus, both from its portability and exceedingly moderate price. It is fitted with good object and eye-glasses, as well as with a mirror, which can be turned to any required angle. It may also be obtained, fitted with additional powers

and with condensing lens attached by a moveable arm. I have one of these latter instruments, made by Messrs. Willats, in my possession, and find it extremely useful for the generality of botanical objects, and indeed for the examination of any specimens where no very great power is required.

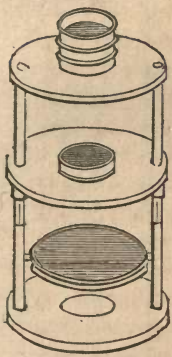


Fig. 9.

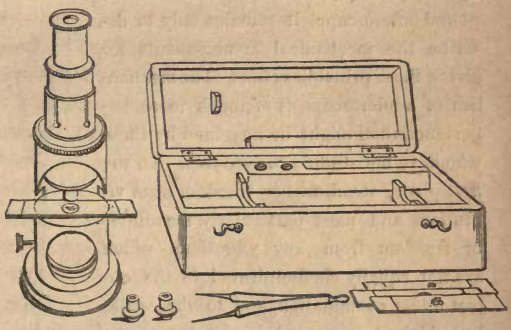


Fig. 10.

16. Compound Achromatic Microscope.—In a treatise like the present, it would be utterly impossible for us to enter into any lengthened details concerning the optical principles involved in the construction of these beautiful instruments, or of the means taken by the optician to correct the chromatic and spherical aberration of the lenses. We must again refer such of our readers who desire to become practically acquainted with the subject, to those treatises of which we have already spoken. (P. 18.)

The annexed engraving (fig. 11) will show the general construction of the form of achromatic microscopes. O is the triple achromatic object-glass. F is a plano-convex lens, called the field-glass, situate in the tube of the microscope, and E E is the eye-glass. These together form the modern microscope. The course of the light is shown by drawing three rays from the centre, and three from each end of the object O. These rays would, if left to themselves, form an image of the object at A A; but being refracted by the field-glass of F F, they form the image at B B, where a stop is placed to intercept all light, except what is required for the formation of the image. From B B therefore the rays proceed to the eye-glass,

exactly as has been described in reference to the single microscope and to the compound of two glasses.

17. Having thus briefly explained the optical principles of the achromatic compound microscope, it remains only to describe the mechanical arrangements for giving those principles effect. The mechanism of a microscope is of much more importance than might be imagined by those who have not studied the subject. In the first place, steadiness or freedom from vibration, and most particularly steadiness or freedom from any vibrations which are not equally communicated to the object under examination, and to the lenses by which it is viewed, is a point of the utmost consequence. When, for instance, the body containing the lenses is screwed by its lowest extremity to a horizontal arm, we have one of the most vibratory forms conceivable; it is precisely the form of the inverted pendulum, which is expressly contrived to indicate otherwise insensible vibrations. The tremor necessarily attendant on such an arrangement, is magnified by the whole power of the instrument; and as the object on the stage partakes of this tremor in a comparatively insensible degree, the image is seen to oscillate so rapidly, as in some cases to be wholly undistinguishable.

One of the best modes of mounting a microscope is shown in the annexed plate, by a reference to which the reader will be enabled to understand the chief features of the arrangements. (Fig. 12.)

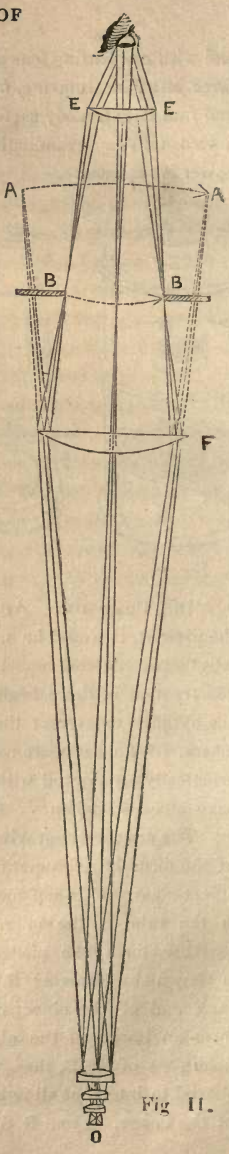


Fig 11.

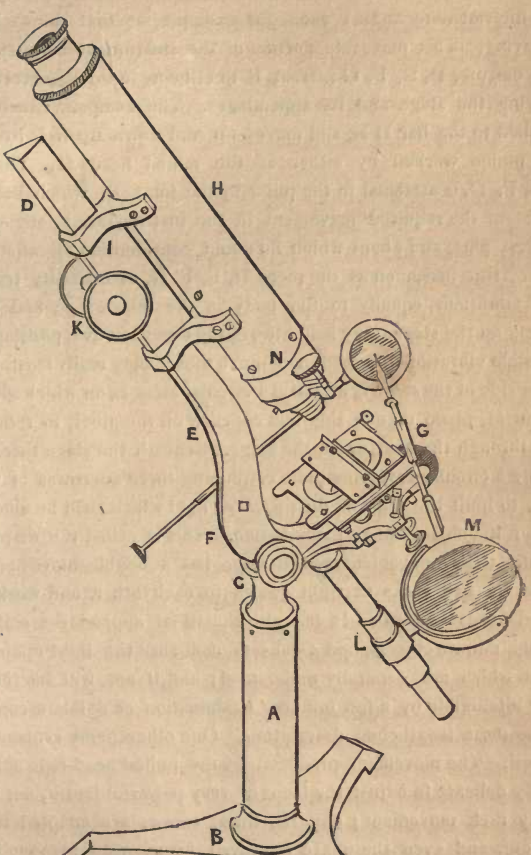


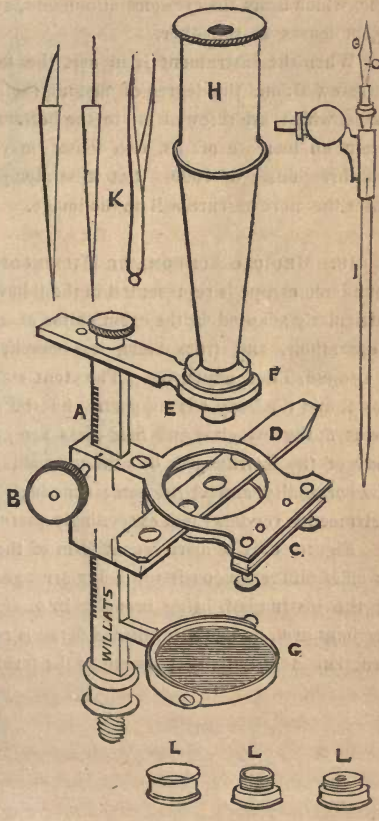
Fig. 12.

A massy pillar A is screwed into a solid tripod B, and is surmounted by a strong joint at C, on which the whole instrument turns so as to enable it to take a perfectly horizontal or vertical position, or

any intermediate angle; such, for example, as that shown in the engraving. This moveable portion of the instrument consists of one solid casting, D, E, F, G; from F to G being a thick pierced plate, carrying the stage and its appendages. The compound body H is attached to the bar D E, and moves up and down upon it by a rack and pinion worked by either of the milled heads H.. The piece D, E, F, G, is attached to the pillar by the joint E, which being the source of the required movement in the instrument, is obviously its weakest part, and about which no doubt considerable vibration takes place. But inasmuch as the piece D, E, F, G, of necessity transmits such vibrations, equally to the body of the microscope and to the objects on the stage, they hold always the same relative position; and no visible vibration is caused, how much soever may really exist. To the under side of the stage is attached a circular stem L, on which slides the mirror M, plane on one side and concave on the other, to reflect the light through the aperture in the stage. Beneath the stage there is generally a circular revolving plate containing three apertures of various sizes, to limit the angle of the pencil of light which shall be allowed to fall on the object under examination. This is called the diaphragm. Besides these conveniences, the stage has a double movement, produced by two racks at right angles to each other, and worked by milled heads beneath. It has also the usual appendages of forceps to hold minute objects, and a lens to condense the light upon them; all of which are generally understood; and if not, will be rendered more intelligible by a few minutes' examination of a microscope than by the most lengthened description. One other point remains to be noticed. The movement produced by the milled head K is not sufficiently delicate to adjust the focus of very powerful lenses, nor indeed is any rack movement; only the finest screws are adapted for this purpose, and even these are improved by means for reducing the rapidity of the screw's movements. For this purpose, the lower end of the compound body H, which carries the object-glass, consists of a piece of smaller tube sliding in parallel guides in the main body, and kept constantly pressed upwards by a spiral spring; but it can be drawn downwards by a lever crossing the body, and acted on by an extremely fine screw, whose milled head is seen at N, and the fineness of which is tripled by means of the lever, through which it acts upon

the object-glass. The instrument, of course, is roughly adjusted by the rack movement, and finished by the screw, or by such other means as are chosen for the purpose.

A more recent and more compact form of this instrument is represented in the frontispiece; but as the difference of construction will be seen by a reference to the engraving, no more lengthened detail is needed. It is the most modern form of instrument, and possesses the advantage of a greater compactness and steadiness, from its being supported on two pillars in lieu of one. This instrument is perhaps the best adapted for educational purposes, from its not being so liable to get out of order.



Figs. 13 and 14.

GOULD'S MICROSCOPE.—A very convenient and powerful form of instrument is that which bears the above name. Its general form is as in the annexed diagram, and the whole fits into a mahogany box.

In the centre of the lid of the box screws the upright square stem A, fig. 14. This has upon one side of it a rack movement, in which works the screw B, intended to raise or de-

press the stage C, as occasion requires. C consists of two plates of brass held together by a spring; between these plates the object slider D is placed. E is an arm at right angles to A; it is attached and confined by the screw at the end of it in A. F must be supposed to represent three lenses, or magnifiers, screwed together, the focus of each being such that they act in unison together. G is a reflector to cast the light upwards through the object to the eye. H is the main tube, which bears the eye-lens at one end, and screws upon one of the object lenses at the other.

When the instrument is in use, the focus is adjusted by moving the screw B, and the degree of magnifying power is according to the lenses, which are screwed on to the bottom of H. Thus, if one lens obtain an increase of 10, two lenses may obtain a power of 100, and three lenses of 1000. Let it be always remarked, that the more lenses the more obscure will be the image.

18. Medical Achromatic Microscope.—Another form of compound microscope is represented in the following outline, (fig. 15.) It is particularly adapted for the examination of anatomical and physiological preparations, and from being less complicated in its arrangements is also much less expensive. The stout stand 3 is screwed into the foot 4, and the body 1 is supported by the arm 2. The object-glasses are at 5, the eye-glass and field-glass are of course contained in the body of the instrument; 6 is the moveable stage, and 7 the mirror. The portability, and at the same time high magnifying power of these instruments, renders them exceedingly useful.

Figure 16 is a more recent form of the same instrument; but as its chief difference consists in being arranged in such a way as to allow of the instrument being brought into any convenient position by the joint at 3, no more lengthened detail is requisite. Its internal construction is essentially the same as the former.

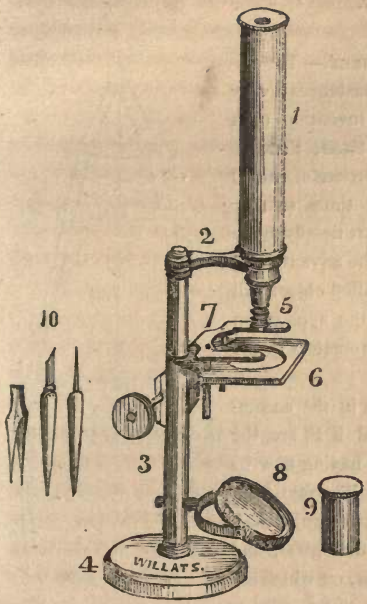


Fig. 15.

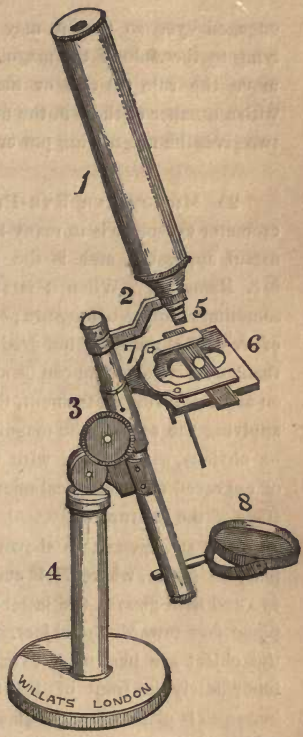


Fig. 16.

19. Method of Measuring the Magnifying Power of Microscopes.—We purpose in the next place to explain the method of ascertaining the magnifying power of the compound microscope; and we are the more anxious to do this, for the reason that it is a fault too common amongst the makers of these instruments to exaggerate the power of the apparatus. The mode of measuring the magnifying power of the compound microscope is generally taken at the assumption, that the naked eye sees most distinctly at the distance of ten inches. Place on the stage of the instrument, a known divided scale; and when it is distinctly seen, hold a rule ten inches from the dis-

engaged eye, so that it may be seen by that eye, overlapping or lying by the side of the magnified picture of the other scale. Then move the rule till one or more of its known divisions correspond with a number of those in the magnified scale, and a comparison of the two gives the magnifying power.

20. MICROMETER EYE-PIECE.—The micrometer eye-piece is in many instances a very useful apparatus, and is the invention of a Mr. Ramsden. When it is stated, that we sometimes require to measure portions of animal or vegetable matter a hundred times smaller than any divisions that can be artificially made on any measuring instrument, the advantage of applying the scale to the magnified object will be obvious, as compared with the application of engraved or mechanical micrometers to the stage of the instrument.

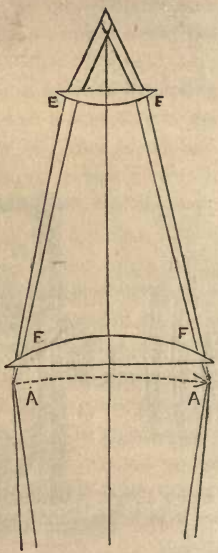


Fig. 17.

The arrangement is shown in the accompanying figure, where E E and F F are the eye and field-glasses, the latter having now its plane face towards the object. The rays from the object are here made to converge at A A immediately in front of the field-glass, and here also is placed a plane glass, on which are engraved divisions of 1-100th of an inch, or less. The markings of these divisions come into focus therefore at the same time as the image of the object, and both are distinctly seen together. Thus the measure of the magnified image is given by mere inspection, and the value of such measures in reference to the real object may be obtained thus; which, when once obtained, is constant for the same object-glass. Place on the stage of the instrument a divided scale, the value of which is known, and viewing this scale as the microscopic object, observe how many of the divisions on the scale attached to the eye-piece correspond with one of those in the magnified image. If, for instance, ten of those in the eye-piece correspond with one of those in the image, and if the divisions are known to

be equal, then the image is ten times larger than the object, and the dimensions of the object are ten times less than indicated by the micrometer. If the divisions in the micrometer and in the magnified scale be not equal, it becomes a mere rule-of-three sum; but in general this trouble is taken by the maker of the instrument, who furnishes a table showing the value of each division of the micrometer for every object-glass with which it may be used.

Chapter III.

ON THE METHOD OF VIEWING AND ILLUMINATING MICROSCOPIC OBJECTS.

21. The art of illuminating microscopic objects is not of less importance than that of preparing them for observation. No general rules can be given for adjusting the intensity of the illumination to the nature and character of the object which is to be examined; and it is only by a little practice that this art can be acquired. In general, however, it will be found that very transparent objects require a less degree of light than those which are less so: and that objects which reflect white light, or which throw it off from a number of lucid points, require a less degree of illumination than those whose surfaces have a feeble reflective force.

Most opticians have remarked, that microscopic objects are commonly seen better in candle-light than in daylight, a fact which is particularly apparent when very high magnifying powers are employed; and we have often found, that very minute objects, which could scarcely be seen at all by daylight, appeared with tolerable distinctness in candle-light. An argand lamp, of somewhat peculiar construction, as represented in the accompanying figure 19, is therefore usually employed. It is made so that the body can be raised or depressed at pleasure, and fixed by a screw. Over the chimney-glass a tube of blackened tin is fitted, so as to allow the light only to pass through a single aperture. A large detached lens also, moving on a slide (fig. 20) is sometimes used to throw parallel rays upon the mirror, and this is generally looked upon as the best artificial light.

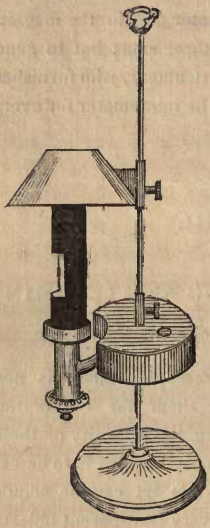


Fig. 19.

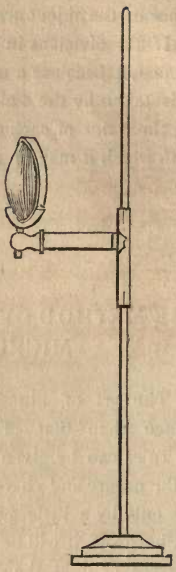


Fig. 20.

22. The following rules, as given by Brewster, may be laid down respecting the illumination of microscopic objects, and the method of viewing them:—

1. The eye should be protected from all extraneous light, and should not receive any of the light which proceeds from the illuminating centre, excepting that portion of it which is transmitted through or reflected from the object.

2. Delicate microscopical observations should not be made when the fluid, which lubricates the cornea of the observer's eye, happens to be in a viscid state, which is frequently the case.

3. The figure of the cornea will be least injured by the lubricating fluid, either by collecting over any part of the cornea, or moving over it when the observer is lying on his back, or standing vertically. When he is looking downwards, as into the compound vertical micro-

scope, the fluid has a tendency to flow towards the pupil, and injure the distinctness of vision.

4. If the microscopic object is longitudinal, like a fine hair, or consists of longitudinal stripes, the direction of the lines or stripes should be towards the observer's body, in order that their form may be least injured by the descent of the lubricating fluid over the cornea.

5. The field of view should be contracted, so as to exclude every part of the object, excepting that which is under his immediate examination.

6. The light which is employed for the purpose of illuminating the objects, should have as small a diameter as possible. In the day time it should be a single hole in the window-shutter of a darkened room, and at night it should be an aperture placed before an argand lamp.

7. In all cases, and particularly when very high powers are requisite, the natural diameter of the light employed should be diminished, and its intensity increased by optical contrivances.

23. As the whole subject of the illumination of objects is of the most important character, I shall make no apology for quoting the remarks of an able microscopist on the subject.* "Much of the beauty," he remarks, "of the objects seen depends upon the management of the light that is thrown upon or behind them, which can only be fully mastered by practice. It may be remarked, however, as a general rule, that in viewing those which are transparent, the plane mirror is most suited for bright daylight, the concave for that of candle or lamp-light, which should have the bull's-eye lens, when that is used, so close to it, that the rays may fall nearly parallel on the mirror; if the bull's-eye lens be not used, the illuminating body should not be more than three inches from the object, the details of which are usually best shown when the rays from the mirror fall upon it before crossing; and the centre should, especially by lamp-light, be in the axis of the body of the microscope. For obscure objects, seen by transmitted light, and for outline, a full central illumination is commonly best; but for seeing delicate lines, like those on the scales of insects, it should be

* Mr. J. Smith, 'Microscopic Journal,' vol. i. p. 48.

made to fall obliquely, and in a direction at right angles by the lines to be viewed.

"The diaphragm is often of great use in modifying the light and stopping such rays as would confuse the image; but many cases occur when the effects desired are best produced by admitting the whole from the mirror.

"The most pleasing light for objects in general is, that reflected from a white cloud on a sunny day; but an argand lamp or wax candle, with the bull's eye lens, is the best substitute."

24. TRANSPARENT AND OPAQUE OBJECTS.—It is generally known that objects for the microscope are sometimes prepared as transparent, at others as opaque objects. In the former instance the light reflected from the mirror is made to traverse, or rather to pass directly through the object; it is, in fact, viewed by transmitted light. In the latter, the light is thrown directly on the object. This may be accomplished in one or other of two ways. By one method a lens fixed to the stage is made to collect the rays of light, and thus to direct them on to the object; in the other the light is thrown up from the mirror on to the metallic specula attached to the object-glasses, (called from their inventor Lieberkhuns,) from which is reflected into the object. A large proportion of opaque objects are seen perfectly well (especially by day-light) with the side illumination; and for showing irregularities of surface, this lateral light is sometimes the best; but the more vertical illumination of the Lieberkhun is usually preferable, the light thrown up to it from the mirror below being, with good management, susceptible of much command and variety.

25. ON VIEWING OBJECTS BY POLARIZED LIGHT.—The addition of a polarizing apparatus to a microscope is an excellent accompaniment to the instrument, whether we consider its peculiar properties, or the brilliant colours it gives to all bodies affected by it. Mr. Pritchard contrived a very simple apparatus for this purpose; it may readily be attached to or removed from the microscope, without either disturbing it or the object under consideration. It consists of two small tubes containing single-image calcareous prisms, or plate of tourmaline, and it is to be used in the same manner as plain diaphragms.

An intense light is to be directed through it, and the instrument adjusted to the object in the usual way, which will present the same appearance as without the tube of prisms. If, however, the second tube be placed near the eye, and close to the eye-glass, the object will appear of the most brilliant colours, if affected by polarized light.

When an object under examination exhibits the colours by depolarizing the light, if the field of view appear luminous, as in viewing transparent objects by common light, cause the eye-piece with its prism-tube to revolve; and in certain positions, the field of view will appear black—the objects assuming at the same time the complimentary colours, and appearing like brilliant gems lying upon black velvet. Many crystals exhibit these polarized tints very intensely. The following, crystallized on a slip of glass, are remarkably interesting, both as regards the elegance of their form and the splendour of their colours. Chlorate of potash, oxalic acid, prussiate of lime, nitrate of potash, and acetate of copper. The great advantage of employing the microscope in viewing the polarized tints of bodies is, that very small specimens will answer equally well with larger and more expensive ones in the ordinary way; and that they do not require any troublesome processes to cut them of different thicknesses for obtaining the different tints, this being accomplished in the process of the chrystallization.

26. Mr. Talbot has directed his attention to this subject; and as the experiments he has published are exceedingly interesting, and may readily be repeated, I have subjoined some of them:—

Sulphate of copper, which is of a fine blue colour when viewed in considerable thicknesses, is white and transparent when it is extremely thin, and its chrystals can be procured so small as to be quite destitute of perceptible coloration. A drop of its solution was placed upon a warm piece of glass, and suffered to evaporate gradually. The crystals shooting out from the edge of the drop into the interior of the liquid had a long and narrow rectangular form, with a slanting extremity, which may be compared in shape to the straight end of a chisel. Seen by common light, these crystals offer nothing peculiar; but on the darkened field of the polarizing microscope, they are luminous and splendidly coloured, the colour depending upon the thickness of the

crystal, and being the same in all points of its surface, except upon the little inclined plane which forms its extremity; but upon oblique portions are seen three or four distinct bands of colour parallel to the edge, and offering to the eye a visible scale or measure of the rapid diminution of thickness in that part. The observed succession of colours in one experiment was the following—yellow, brown, purple, blue, sky-blue, straw-yellow, pink, green, bluish green, pink.

Sulphate of copper, with a drop of nitric æther added to the solution, on a slip of glass, produced minute crystals in the form of rhomboids. These, when placed under the microscope with the field dark, appear like an assemblage of brilliant rubies, topazes, emeralds, and other gems, each being of a different thickness, depolarizing the light in a different degree. If the polarizing eye-piece be now turned a quarter round, the field becomes luminous, and the crystals assume the complimentary colours. Many other salts offer interesting results. Some, however, crystallize in such thin plates, that they do not sufficiently depolarise the light to become visible in the dark ground, such as the minute crystals of sulphate of potash precipitated by æther; but even these may be often rendered visible when placed on a plate of mica. The beautiful property of dichroism, discovered by Sir D. Brewster, in acetate of copper, may also be exhibited without any trouble, with the polarising microscope.

Many organic substances appear luminous when the field is darkened, while others are inert, having no sensible action on the polarized light.

Fragments of coarsely-powdered sugar and of various salts appear more or less bright, and mottled with various colours. Common salt remains dark, and does not act upon the light.

27. Test Objects.—It is perhaps one of the greatest requisites in the selection of a microscope, to be able to ascertain whether it will be efficient for the purposes intended. This can only be known by its capability of exhibiting those objects submitted to it. Till very recently it was not ascertained that certain objects, in order to render their various markings or texture distinctly apparent, required the instrument to be of the best construction, whether single or compound, and possessing a considerable quantity of distinct light. These objects

have therefore been denominated tests, by their discoverer Dr. Goring. In order that the reader may be able justly to appreciate the efficiency of any microscope that may come within his observation, and determine its penetrating and defining powers, whether the instrument be single or compound, I shall describe the principal test objects necessary for that purpose. The objects best adapted to determine the penetrating power are the dust or scales from the wings of certain classes of papilio, (butterflies and moths.) Of these, the *menelaüs*, shown in figures 21 and 25 of the following illustration, is a very useful object. The dust from the under side of the wing of the male papilio brassica, (white cabbage butterfly,) shown in fig. 22, is a good proof object; and a very peculiar one of the same kind is shown in fig. 24, (both magnified.) In viewing these objects, a large angle of aperture is required, (at least equal to half the focus,) in order that the lines and markings may be distinctly seen.

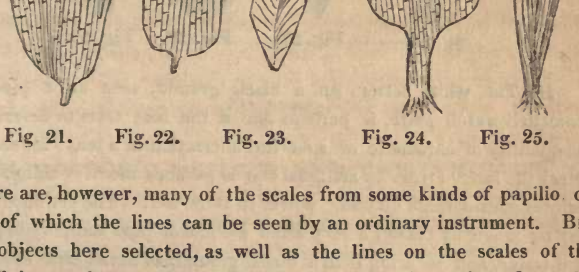


Fig 21. Fig. 22. Fig. 23. Fig. 24. Fig. 25.

There are, however, many of the scales from some kinds of papilio on any of which the lines can be seen by an ordinary instrument. But the objects here selected, as well as the lines on the scales of the small brown house moth; the lines on the scales, taken from the foreign curculio, (diamond beetle,) fig. 23, require a more perfect instrument to develope them.

Mr. Pritchard recommends for this purpose, the scales from the wing of the Euplœa limniace, and the blue ones from the Papilio Paris as valuable objects, as the cross striæ on them are strongly and easily developed under a power of from 100 to 200 times linear.

Lastly—The most difficult of all the test objects, are the lines on

the scales from the *podura springtail*, discovered by Mr. T. Carpenter, and on which the scales are only just discovered by the most perfect instruments. When the penetrating power is thus ascertained, its defining power may be determined, by inspecting a leaf of the moss of a species of the genus *hypnum*, which requires a considerable penetrating as well as defining power fully to develop the hexagons which constitute its fabric, making out a luminous nucleus to each which should be sharply defined; and of the same shape with the outer hexagon. As opaque test objects, the bat's hair shown in figs. 26 and 27, and the mouse hair, figs. 28 and 29, may be considered excellent tests, when the markings and outlines are well defined. These objects may be also examined with transmitted light with the same advantages.

Fig. 26.

Fig. 27.

Fig. 28.

Fig. 29.

28. The white letters on a black ground, seen on a piece of enamelled watch plate, is perhaps one of the best tests to determine the quantity of chromatic or spherical aberration in a lens; indeed, to detect the latter error, an artificial star is perhaps the best thing, as it requires considerable defining power to show well. The artificial star may be made by taking a very small globule of pure mercury kept in gum-water, and securing it to a black ground, as burnt cork or black paper, or a globule of platina fused by electricity, and attached to a black ground.

29. In examining these test objects, the direction and quantity of light must be carefully attended to, nor must it be injured or mutilated by the reflector, condensing lens, or other diaphonous body through which it may pass to the object. When an instrument can show these proof objects, it may with certainty be pronounced effective. It

should be remarked, that when the objects are used as opaque, a smaller aperture will do best, namely—about two-fifths of its focus. For transparent objects, a larger aperture is absolutely necessary; and for some tests it should be equal to its focal distance, to show the cross striæ between the lines on many of the scales when the power of the instrument or lens is considerable. It is worthy of remark, that the same aperture that with advantage will develop one class of objects will not show another with the same success.

30. As a conclusion to the subject of test objects, I shall quote the valuable remarks of Mr. Pritchard, in a little work published some time since:—"It cannot too strongly be impressed upon an observer, that of two instruments, the one which shows the object with the least power is always the best. This, of course, will not suit the lovers of the marvellous, who would rather see a flea appear as big as an elephant, though they lost all its finer markings, than have them preserved when moderately magnified. Another class of observers, who admire high powers for the microscope, are those whose sight is so defective that they cannot otherwise see a very minute object."

Chapter IV.

MICROSCOPIC OBJECTS AND THEIR MOUNTING.

31. Every department of nature is full of objects, from the examination of which the most important discoveries have already been and still may be expected to be made. But though the zealous observer can never be at a loss for subjects of research, it is desirable to know what has been done by our predecessors, and what trains of enquiry are likely to prove of the most general interest; for it is more particularly for the use of the general examiner that this little treatise has been written. It may, however, be again necessary to remind the reader, that as the work is intended only as a practical guide to the microscopical student, it is not the intention of the author to enter

into any details concerning the natural history of the objects described or named.

32. TRANSPARENT OBJECTS.—The general method of preserving these objects in a dried state, is between very thin plates of talc or mica fitted into cells formed in ivory sliders, having a split ring of wire to secure them, as in the following outline, (fig. 30.) The bottom of the cells should be turned quite flat to afford a good bearing for the mica, and of sufficient thinness to permit the magnifiers to approach the object. In using these sliders, like everything else, there is a wrong and a right side, which must be observed, or the student will not be able to approach close enough to the object with the high powers. The ring side should always be placed downwards, or from the microscope, and the other side next the eye or instrument. The softness of mica prevents its being cleaned like glass; it should therefore be kept as free as possible from dust, and only brushed lightly with a camel's hair pencil when necessary, and never touched by the fingers. Generally speaking, four, six, or even a greater number of cells are formed in each slider. When test objects are to be mounted in this way, only one or two cells should be made in each slider, which will lessen their liability to injury.

Fig. 30.

33. Another and an excellent method of mounting transparent objects is on slips of glass. A number of slips of glass of an uniform size should be procured, so that they can be fitted into a cabinet or otherwise. The dimensions to be employed are of course arbitrary; but it will be generally found, that the three following sizes are the most useful:—the first, 3-inches long and $\frac{7}{8}$ of an inch wide; the second, for smaller objects, 2-inches long and $\frac{5}{8}$ of an inch wide; and the third, $1\frac{1}{2}$ inches long and a quarter wide. The two first, when used for transparent objects, have a slip of paper pasted on one side with an aperture about one-third from the end; in the centre of which, beneath a plate of talc, the object is to be placed. It is better

to have a number of these blank sliders with the paper and talc pasted down at one end ready for use, for it often happens that many a valuable object is lost from not having a convenient receptacle for it when it presents itself.

34. In lieu of glass or ivory, a celebrated Microscopist uses small strips of mahogany veneer, with a hole bored through the centre, into which a piece of glass is fitted to place the object on. In either of these methods, the object is to be fastened to the glass by means of Canada balsam, the glass being warmed previously to its application. This renders objects extremely transparent and beautiful.

35. There are some objects, such for example as the larger wings of butterflies, which are not sufficiently transparent when mounted in either of the above ways. Mr. Pritchard has, however, devised a plan by which they may be exhibited with singular beauty and intensity of colouring. It consists in immersing the object completely in Canada balsam, and pressing it between two slips of thin glass, so as to exclude the air bubbles. The sides of the glass are then to be thoroughly wiped, so as to remove all superfluous moisture, and brushed over either with gold size or marine glue, the composition of which will be found explained further on. By this treatment, many objects which otherwise possess little interest, are rendered highly valuable, allowing the light to pass freely through them, exhibiting their structure, and presenting the most brilliant and superb colours. By this method also many cylindrical bodies are rendered perfectly distinct, the diffraction at the edges being in a great measure destroyed by the refractive power of the medium. In objects prepared in this way, we are able to perceive whether the cylindrical part be hollow or solid; for when the former, they are often as finely injected as if by design.

It may be well to remark, with transparent objects generally, that, to observe all the minutiæ of the most delicate, particularly those which are called test objects, they should be placed upon a clear slip of glass without an intervening medium; but if such must be used, they should be covered by a piece of very thin glass, as mica injures in some degree the rays of light proceeding from minute and delicate objects. It is only for the more common and least delicate forms of objects that the mica is useful.

36. Mounting Opaque Objects.—The smallest glass sliders, of which we have spoken, (section 33,) are exclusively used for opaque objects. On to one side of them is cemented, near the end, a piece of soft leather or cork, punched out into circles of a convenient size; the leather or cork being previously blackened, or covered with black paper. A pin run through the leather, holds the object conveniently. Sometimes these cylinders are made of ivory, but in all cases it must be remembered, that in order to render them fit as a back ground, they must be blackened. The darker the object the more black and sombre must be the mounting, to heighten the brilliancy of the object by the contrast. The best means of fixing the objects in this mounting, is a solution of isinglass and gum arabic in spirits of wine, which affords a strong and tough glue.

37. Mr. Cooper, the editor of the Microscopic Journal, remarks, that the plan of mounting opaque objects on a dead back ground, generally black paper is objectionable, on account of the small fibres on the surface of the paper reflecting some considerable portion of light. The plan he recommends for mounting minute objects, to be viewed either opaque or transparent, is simply by placing them on a piece of crown glass with a little weak gum-water, and surrounding them to the extent of a quarter of an inch or more with a rim of cardboard sufficiently thick to prevent the object being removed or broken when another slide is placed either intentionally or otherwise upon it. By using the stop of the diaphragm the object is made opaque, and an even and uniform dark-coloured field is by this means obtained.

38. Mounting in Preservative Fluids.—Some objects, more particularly the microscopic infusoria, are generally deemed only to be interesting when seen alive, because from their peculiar structure they cannot be preserved for occasional inspection in the usual ways. This difficulty, however, may be removed, by preserving them in alcohol or other preservative fluid—a valuable resource, as it enables us to retain, with little injury, their general structure. By this means creatures which are new may be saved from entire demolition, and secured until their *genus*, *nature*, or usual *habitat* can be ascertained.

39. The method of mounting in alcohol or spirit of wine, is as

follows:—Take a slip of glass and cover it on one side with a coat of painter's white-lead, leaving a space in the middle large enough to contain the object to be mounted; when this coat is dry, add another, and proceed thus until a sufficient thickness is obtained for the enclosure of the object to be mounted. The next thing is to procure a clear piece of mica, free from veins and flaws, and rather smaller than the slip of glass. Fill the cavity with spirits of wine, place the object therein, and cover it with the plate of mica, which must be brought into close contact with the white lead, by gently pressing it with a smooth piece of wood from one extremity to the other, so as perfectly to expel the air bubbles. In a few days, the white lead will have become hard; and if the mica be sound, the enclosed specimen may be preserved for years. Instead of the mica, a piece of thin glass of the same size as the former may be laid on the surface of the white lead, and the edges kept together with marine glue.

40. Goadby's Method.—But the best and most valuable preservative fluid with which we are acquainted, is that discovered by Mr. Goadby, of which the following is the formula*:—

Bay Salt	4 ounces
Alum	2 ounces
Corrosive Sublimate ..	4 grains
Boiling water	2 quarts.

These ingredients are to be stirred well together, and when cold, strained.

Preparations immersed in this fluid keep their colour well, even those possessing a delicate rose tint, such as the blood corpuscules. In mounting objects for the microscope with this fluid, the following method may be adopted. If the object be flat, it will be only necessary to place it on a slip of glass, to drop on to it a little of the fluid, and then press on to it another piece of glass of a similar size—the superfluous moisture is then to be wiped from the edges of the two pieces of glass, and they are to be kept together by brushing the edges over either with gold size or marine glue. If the object be not

* This solution is equally valuable to the zoologist. No preservative fluid hitherto discovered, is equal to that of Mr. Goadby. Specimens thus put up, preserve all their beauty of form, flexibility, and natural colour.

flat, then the process described (section 39) must be resorted; Mr. Goadby's solution being substituted for the spirit of wine.

41. The marine glue is certainly the best cement for joining pieces of glass together, and it is also very useful in forming the cells for the reception of microscopic objects in lieu of the coatings of white lead, of which we have already spoken, (section 39.) It is made thus—one pound of caoutchouc is to be dissolved by maceration for several days in four gallons of coal naptha, and with one pint of this solution, two pounds of shellac are to be mixed by heat When the fusion is complete, it is to be poured out on a cold slate, and moulded into convenient forms for use. When cold, it is as hard as wax. It is applied by gently heating the glass, and then rubbing on the glue. So tenacious is its hold, that the joint will rarely, if ever give way,—the glass may be shivered to atoms, but the joints will remain firm as ever.

42. The following mode of preserving the crystals of salts, as permanent objects for the microscope, and for the exhibition by that instrument of the phenomena of polarized light, is due to the researches of Mr. Warrington. The method to be adopted in mounting the specimens, is as follows:—A warm saturated solution of the salt required is to be prepared, and a drop of it placed upon the glass slider on which it is intended to be permanently mounted, and allowed to crystallize; when a good group of crystals is obtained, the uncrystallized portion is to be cautiously removed,—this is best effected by drawing it gradually away in a small stream along the edge of the slider: having previously broken through that part of the crystalline ring adjacent to the edge, the salt is to be allowed to drain itself quite dry, by placing the slider on its end in a vertical position. It should next be examined, under the microscope, to ascertain the fitness of the crystals for the purposes required; because many salts separate from their solutions in crystals too thin to exhibit any prismatic colours when viewed by polarized light, appearing only of a pearly or silvery aspect, while others form in the opposite extreme, and are totally unfit, from their thickness, for investigation. Presuming, however, that the crystals are such as the investigator requires, the next step

is to drop on a small quantity of castor-oil—that which has been filtered cold must be employed, as otherwise it is liable to the same objection as olive-oil; and care must be taken that it covers the whole of the salt, and has displaced all the particles of atmospheric air that may have been adhering to the crystals. This having been done, a small piece of very thin glass is to be carefully placed on the surface of the oil, and any excess which may by this means have been pressed out cautiously removed by bibulous paper from the edges. The margin may then be covered by a coating of marine glue, a strong varnish of shellac or gold-size, and the crystals are permanently preserved for observation. If varnish be used, one layer of it should be allowed to dry for twenty-four hours, before the next is applied; and during this time, the slides must be maintained in a flat position.

Chapter V.

MICROSCOPIC OBJECTS AND MEANS OF PROCURING THEM.

43. I have already observed, that every department of nature is full of objects of the greatest interest, when examined beneath the microscope. To all these it is impossible even to allude; but it is my intention, in this section of the work, to refer to some of the more interesting classes of objects, and the method in which they may be obtained and prepared for examination; thus, in fact, giving a kind of outline of the extent of the use of the microscope.

44.—Botanical Objects.—The elementary organs of plants require the assistance of the microscope to render them apparent. The forms of the elementary organs of plants are, 1, Cellular tissue; 2, Woody fibre, and 3, Vascular tissue. Cellular tissue composes the pith and soft parts of plants, and consists of distinct vesicles of various forms cohering together. Sections of the calycanthus floridus,

young branch of the misletoe, and the pith of the rubus odoratus, present all the varieties.

Woody fibre is best observed in vertical sections, cut either parallel or perpendicular to the medullary rays. It consists of a series of cells, which differ in exogens and endogens, and therefore sections of both are extremely interesting. What is called glandular woody fibre is peculiar to resinous woods, as the pine, which offers a good example. In this case the microscope has greatly assisted geology, by proving from this glandular structure that the coalbeds have been principally composed of ferns and pines.

Vascular tissue presents the most varied and interesting subject for microscopic examination; it consists of membranous tubes, internally furnished with fibre. The elder and asparagus give excellent specimens of this tissue.

45. Sections of Trees and Plants.— There is much tact required in preparing good and perfect sections of woods and plants. The specimens from which they are to be cut must be in a proper condition; the section should be of a uniform thickness, and the various tissues and vessels unbroken. Indeed, an instrument is required for the purpose of cutting them properly. The following is one which is at the same time convenient and efficacious. A represents a solid table of brass, about six inches long, four wide, and a quarter of an inch deep, with a guide or stay-piece, rising above the general surface at the back edge B. C is a hole through A, fitted with a short cylindrical socket, that extends below the under surface of A; it is close at the bottom, except that the screw passes through it. The head of this screw is made by a toothed wheel E, containing ten teeth, while the screw itself contains thirty threads to the inch. The use of this screw is to move up or down a brass cylinder with a square hole in it; the top of this is seen at D. The wheel, E, is kept in its place by the spring F. I I is a three-sided brass frame, which has a sharp razor-blade across it at I. K is the wooden stand to the whole. When used,

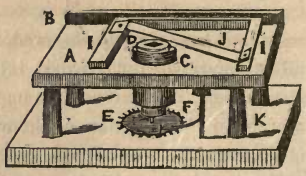


Fig. 31.

the wood to be cut is fixed tightly in the square hole D; the socket put into its place and adjusted by the screw below. The knife being then pushed forward will cut off a slice of wood; upon turning the wheel one tooth, and again moving the knife, a second slice will be obtained, and so on. These sections, if good, should float in spirits of wine. To form a proper idea of the structure of any plants, three sections should be made, viz:—one horizontal and two vertical, one of the latter being parallel to and the other perpendicular to the medullary ray.

46. The pollen or farina from the flowers of plants, the seeds of plants, the cuticles, and stomata or orifices in the cuticle, form a pleasing class of opaque objects. The spohrs of ferns, usually found in cells beneath the leaf, are likewise curious opaque objects. But one of the most interesting classes of botanical objects are the algæ which include the confervæ and fuci or sea weeds. In some of the latter plants, more particularly, the microscope enables us to observe the bursting of the cells, the release of the sporules, which become fringed with a number of cilia, by the motion of which the new being is able to traverse the water, until it finds a spot fitted for its future growth, to which it then becomes adherent. The same thing is observed with regard to the germ of the sponge: and here we have a remarkable similarity between the reproduction of a vegetable and animal being. Some of the small disjointed algæ are closely allied to animalcules, in which a circulation has been detected, and apparently a spontaneous motion. They are found in ditches and stagnant pools.

47. Fossil woods, when polished, are excellent opaque objects, and exhibit most of the characteristics of the original plant. But by far the most interesting specimens from this class of objects, are made by cementing very thin sections on to sliders, which may then be viewed either by reflected or transmitted light.

48. Microscopic Shells—Minute foramina, and other shells and remains, form an interesting series of objects to the lovers of microscopic research. The procuring of specimens of these minute fossils is generally considered difficult. But the following method recommended by Mr. Bowerbank * is simple, and within the reach of all:—"If the

* Microscopic Journal, vol. i. p. 21.

sand and dust, shaken out of the West Indian sponges into the bins or casks in which they are kept by dealers, be swept up and examined, it will be found to abound in minute shells, corals, and other interesting remains of marine animals; and among them many species of *foraminifera* are found, which appear very closely allied to many of the same family that I have seen in the fossil state. Species of echini, spicula of sponges, and an infinite variety of minute organic remains will reward the researches of the observer. The sponges themselves, in the state in which they are imported, are also well worthy of the trouble of a careful examination, especially those parts that are usually trimmed from the base, as being too full of impurities to be sold; many very beautiful specimens are thus found attached to the fibres of the sponge. I have not found many organic remains in the sand shaken out of the Turkey sponges; but it is probable that if the sand from such sponges, obtained from other localities, were to be carefully looked over, new and interesting objects would be the result of such an investigation."

49. SHELLS IN CHALK.—Many, and probably all, white chalk rocks are the produce of microscopic coral animalcules, which are mostly quite invisible to the naked eye, possessing calcareous shells, of which more than one million are well preserved in each cubic inch, that is, much more than ten millions in one pound of chalk. The extreme minuteness of the chalk animalcules is strikingly proved by this, that even in the finest levigated whiting, multitudes of them are still present, and may be applied, without suffering change, to the most varied technical purposes; thus, in the chalk coating given to painted chambers, paper, or even glazed visiting cards (when not coated with white lead alone) may be seen a pretty mosaic of well-preserved moss-coral animalcules, but which are invisible to the naked eye; and thus our natural vision receives from such a surface the impression of the purest white, little dreaming that it contains the bodies of millions of self-existing beings of varied and beautiful forms, more or less closely crowded together.

The best method of examining into the animalcular composition of chalk, is that recommended by Ehrenberg,* which is as follows:—

* Ann. Natural History, June, 1841, p. 309.

"Place a drop of water upon a lamina of mica, and put into it of scraped chalk as much as will cover the fine point of a knife, spreading it out, and leaving it to rest a few seconds; then withdraw the finest particles, which are suspended in the water, together with most of the water, and let the remainder become perfectly dry. Cover this remainder, so spread out, with Canada balsam, and hold it over a lamp until it becomes slightly fluid, without froth. A preparation thus made seldom fails; and when magnified three hundred times in diameter, we see that the mass of the chalk is chiefly composed of minute well-preserved organisms." The fossil animalcules in chalk, according to Ehrenberg, amount to twenty-one genera, and forty species.

50.—ANIMALCULES.—It is, perhaps, one of the easiest things connected with microscopic research, to procure animalcules. In all stagnant waters—in the scum of all decaying vegetable infusions—in fact, in all stagnant waters containing infusions of organised matters, these animalcules are to be obtained. The surface of infused liquors is generally covered with a thin pellicle which is easily broken, but acquires thickness by standing; the greatest number of animalcules are generally to be found in this superficial film. In some cases they are so extremely numerous, that it is necessary to dilute the infusions; but this is always to be done with *distilled* water, and this water should, for the sake of accuracy, be previously examined with the microscope before it is made use of; the neglect of this precaution has been a source of many errors. To place these minute animalcules under the microscope, the best method is by means of the feeding pin, represented in the annexed diagram. It consists of a glass thread inserted into

Fig. 32.

a convenient handle, the end of the glass being enlarged like the head of a common pin, which is to be dipped into the infusion. In this way a small drop of the fluid containing them may be placed on a slip of glass, and covered with a piece of talc, to prevent evaporation, and at

once subjected to examination. When it is desirable to examine the contents of different infusions, the feeding pin should be washed in distilled water between each dip, to prevent mixing. An infusion of common black pepper and of the red cabbage, if left exposed to the air for a few days, are excellent media for the production of animalcules.

51. There are some animalcules, to procure which requires greater care and more trouble; such, for example, are the eels in paste. The following is the readiest method of obtaining these. Boil a little flour and water till it comes to the consistence of such a paste as is used by bookbinders or shoemakers. This paste should be made from flour and water only; that of the shops, containing resin and other matters, is unfit for the purpose. Expose it to the air in an open vessel, and beat it from time to time with a wooden spatula, to prevent its surface becoming hard or mouldy. After a few days, particularly when the weather is warm, it will turn sour. Then if it be examined with attention, myriads of eels will be found on the surface. When they are once obtained, their motion on the surface of the paste will prevent any mildew, and it therefore requires no further attention. In like manner it will prevent its freezing in winter. If the paste be too thin, they will creep up the sides. In this case, a portion of very thick paste must be added to preserve them. When it is desirable to give them a fresh supply of food, it must not be put upon them, but they must be placed upon it.

To prepare them for the microscope take a few drops of clean water, and put a very small portion of the paste containing the eels into it. After it has stood a minute or two, the eels may be taken out and placed under the microscope, freed from a considerable portion of foreign matter.

52. Wheel Animalcule.—The Vorticella Rotatoria, or Wheel Animalcule, is another most interesting object for the microscope. In many works directions are given to search for them in leaden gutters, but the search of the microscopist in such situations will rarely be successful. The best method of raising and preserving them is as follows. Early in the spring fill a three-gallon jug with pure rain water, (not butt water, for the larvæ of the gnat tribe will then be mingled with them.)

This quantity suffices to fill a half-pint mug, and to keep it at the same level during the season. Then tie up a small portion of hay, about the size of the smallest joint of the little finger, trimming it so that it may not occupy too much room in the mug, and place it in the water; or the same quantity of green sage leaves will do. Every ten days the decayed portion should be gently removed with a piece of wire, and a fresh supply substituted. By either of these methods a good supply of wheel animalcules can always be kept up.

53. Polypi.—These animals, which are exceedingly interesting microscopic objects, are to be found upon all sorts of aquatic plants—upon branches of trees, pieces of board, rotten leaves, stones, and other substances that lie in the water. They should be sought for in the corners of ditches, puddles, and ponds, being generally driven into these with the pieces of wood or leaves to which they have attached themselves. They are seldom to be met with in winter; about the month of May they begin to appear and increase. They are generally found in waters which move gently, for neither rapid streams nor stagnant waters ever abound with them. I have drawn attention to these animals, because they are, probably, the most convenient for viewing the internal organization of animalcules. Their usual food assimilates so closely in colour to themselves, that it is impossible, under ordinary circumstances, to perceive the form of their digestive functions. Mr. Trembely, and, subsequently, Dr. Ehrenberg, have pursued the plan of feeding them with minutely divided solutions of coloured substances, such as indigo, carmine, and sapgreen, and by this means have ascertained the form of the digestive cavities in animalcules. It is essential that whatever colouring matter we employ should be pure and free from impurities, and that it be only mechanically not chemically soluble in water.

54. Mode of selecting Aquatic Larvæ and other Small Animals.—It is usual, for the purpose of thoroughly examining them, to obtain a quantity of the animalcules, found in stagnant pools or gentle streams, and to preserve them in convenient vessels. Although they are usually visible to the naked eye, yet it is difficult to select a specimen for examination, their organization being so delicate as not to allow of

their being touched. Two methods are usually adopted for this purpose, both of which are exceedingly convenient. The first instrument used is simply a glass tube at both ends. The upper end of it is to be held between the fingers, and the orifice closed by the thumb; the lower end is then to be immersed in the vessel of water, and the instant the animalcule required approaches the tube, the thumb is to be removed from the upper extremity, and the pressure of the atmosphere will force the water with the insect up the tube, when the thumb is again to close the upper appertnre, and the tube with the object is to be removed. These tubes may be of different diameters to suit the various objects.

55. Some of the larvæ of insects are very delicate, and require very gentle means for removing them for examination. This may be very carefully done with the net spoon, an instrument similar to the accompanying outline. It consists of a wire bent in the peculiar form shown, and covered by a piece of muslin or net.

Fig. 33.

56. Insects.—The insect kingdom presents innumerable objects of interest to the microscopist. The antennæ or horns—the wings—wing-cases—the structure, number, and form of the eyes—the structure of their feet—their tongues and mouths, all form an interesting and necessary branch of enquiry, which will amply repay an attentive and minute examination. Most of these are opaque objects, with the exception of the wings, which in many cases may be viewed as transparent objects, particularly when prepared in the way already advised, (section 37.) To prepare these objects, great patience is required, inasmuch as they should be separated without injury from the body of the animal. In this dissection a very fine pair of scissors will be found of utility. It is requisite that their cutting edges should be exceedingly fine. Instruments for the purpose, can be obtained of most

optical instrument makers. Two very fine needles mounted in small handles are exceedingly useful in separating the various organs of insects; or the forceps, the knife, and point K, Fig. 13, will be found admirably adapted to aid the microscopist in his dissections, either before or while the object is beneath the miscroscope.

57. Anatomical Injections.—In the minute structure of the organs and tissues of higher animals, the microscope has been of the most essential service. The injection of these preparations is rather the province of works on anatomy; and I shall only here refer to a new method of injection, which, from its minuteness, is more particularly adapted to the microscope.

M. Doyere has devised a method for obtaining minute injections of the greatest utility in the examination of such structures beneath the microscope. The process consists in causing to enter in the same vessels, within a certain interval of time, two finely-filtered saline solutions, which, by double decomposition, give an abundant and opaque precipitate. The second solution is injected as soon as the first has passed from the arterial system into the venous and lymphatic systems.

M. Doyere has made a great number of experiments on the subject, from which he is led to prefer, to all others, the chromate of lead. He first injects a solution of chromate of potash; and it is to be remarked, that the order of injection is a point not to be neglected. A limpid solution of acetate or nitrate of lead is then injected, and a beautiful yellow injection is the result. A blue colour may be obtained by the precipitation of Prussian blue: brilliant red, of iodide of mercury; white, of carbonate or sulphate of lead from the usual solutions.

58. Teeth and Shells.—Sections of the teeth of various animals are beautiful microscopic objects. The principal substance of the teeth in almost all animals, is one called *Dentin*, characterised by minute tubular passages permeating it in a direction from the centre to the circumference. Considerable variation in the arrangement of these tubula is found in different groups of animals, which enable naturalists to determine, with great precision, by the microscopic examination of

even small fragments of ivory, the animal to which the tooth belonged. Shells also present beautiful appearances beneath the microscope. The shell of the echinus, or sea urchin, for example, is found to be composed of a network of calcareous matter, sometimes forming a series of plates parallel to each other, and connected with little pillars proceeding from one surface to another. In the spine, with which the animal is covered, this network has a most beautiful appearance. The shells of moluscs have been shown by the microscope not to consist of mere masses of calcareous matter, as a piece of limestone is, but are distinguished each by some peculiarity of structure, which the microscope exhibits to us. Primarily the shell of a molluscous animal is composed of cells of animal matter, in which are contained calcareous matter. In many cases, the shells are of a prismatic form, and the internal matter takes its shape from the cells. Here again the naturalist, by seeing the smallest fragment of shell, or even a little of the calcareous dust left when the membrane was discharged from it, can tell to what tribe of molluscs it has belonged.

59. Circulation in Animals and Plants.—One of the most interesting active phenomena exhibited by the microscope, is the circulation of the nutritious fluids in animals and plants. In the former, the globules of blood may be seen passing rapidly along the capillary ends of arteries into those of the veins when the intervening membrane is sufficiently diaphonous, as in the ear of the young mouse, the fins and tail of the carp, gold-fish, stickleback, tadpole, and of most small fish, and in the web between the toes of the frog, lizard, etc. etc. It need hardly be remarked, that in order to observe this phenomenon, the animals should be alive and fastened securely upon the stage of the microscope—the part to be examined, stretched before the object-glass, and a strong light directed through it.

Mr. Pritchard states, that in the Arachnoida, (spiders,) the circulation may be observed very distinctly, the currents of dark globules passing rapidly at each pulsation of the dorsal vessel. In the antennæ and wings of terrestrial insects, it has also been seen when they have just emerged from the chrysalis, as in the Perla Viridis, and Semblis Bilineata. In several aquatic larvæ and small curstacea, the circulating fluid appears to traverse the limbs, antennæ, and tails, and thence

moves along the dorsal vessel towards the head and down the sides of the body, in cavities and not distinct vessels; hence called diffused circulation. Even in the lowest forms of animal life, in the Acalephæ Infusoria and Polypi, it has been asserted, that the circulation has been observed; but these observations may be considered as liable to fallacy, on account of the prevalence of various kinds of ciliary currents in the interior of many of these animals. The striking analogy which these currents bear to those occurring in the stems of some plants, as Chara and Caulinia, seems to bring them under another class of phenomena, than those of the vascular circulation of the higher animals. The most favourable subjects for viewing this diffused circulation, are the larva of the ephemera—the larva of the hydrophilus—the water-flea (daphnia pulex.)

The circulation in plants termed cyclosis, is a revolution of the fluid contained in each cellule, and is distinct from those surrounding it. It can be observed in all plants in which the circulating fluid contains particles of a different refractive power or intensity, and the cellules of sufficient size and transparency. Hence all lactescent plants, or those having a milky juice, with the other conditions exhibit this phenomenon. The following aquatic plants are generally transparent enough to show the circulation in every part of them:—Nitella Hyalina, Nitella Translucens, Chara Vulgaris, and Caulinia Fragilis. In the frog-bit, (Hydrocharis,) it is best seen in the stipula of the leaves and the ends of the roots. In the spider-wort, (Trandescantia Virginica,) it is seen in the filaments surrounding the stamens of the flower. In the common groundsel, (Senecio Vulgaris,) it is said to be seen in the hairs surrounding the stalks and flowers.

60. In the foregoing pages, it has been the intention of the compiler to give a clear detail of the practical use of the microscope, and to explain its manipulation. As stated in the outset, this was the chief intention of the work; but it was found impossible to omit some reference to the wondrous revelations of this instrument. This sketch of the extent and variety of the discoveries effected by the microscope, is, from the limits of the work, necessarily a brief one. The continued use of the microscope, and the researches of naturalists into the infinitude of the organized creation, have been the means of

bringing to light great numbers of living beings, of whose existence but a few years back we had no reasonable proof. From the chilly regions of the Glaciers, with their coloured snow, to the pools of Egypt, with their living forms; from the waters of the Cattegat to the sunny waves of Mexico; from the Bergmehl of Finland to the brown mould of Newmarket; has the enquiring mind of the naturalist drawn evidence of the all-pervading principle of life. Forms, from whence the essence of vitality has long since departed, have given up their remnants from the chalk, and beings invisible to the naked eye of man have been summoned from their entombment in their flinty sarcophagi. The chaos of old systematists has passed away, and a structure of beauty has been formed from its heterogeneous materials. From the constant accessions to our knowledge of microscopic life, we cannot but acknowledge the truth of the poet's description—

"Full nature swarms with life—one wondrous mass
Of animals or atoms organised—
Waiting the vital breath, when parent Heaven
Shall bid his spirit blow. The hoary fen
In putrid streams emits the living cloud
Of pestilence. Through subterranean cells,
Where searching sunbeams scarce can find a way,
Earth animated heaves. The flowery leaf
Wants not its soft inhabitants. Secure,
Within its winding citadel, the stone
Holds multitudes. But chief the forest boughs,
That dance unnumbered to the playful breeze,
The downy orchard, and the melting pulp
Of mellow fruit, the nameless nation feed
Of evanescent insects. Where the pool
Stands mantled o'er with green, invisible,
Amid the floating verdure, millions stray.
Each liquid too, whether it pierces, soothes,
Inflames, refreshes, or exalts the taste,
With various forms abounds. Nor is the stream
Of purest crystal, nor the lucid air,
Though one transparent vacancy it seems,
Void of their unseen people. These, concealed
By the kind art of forming Heaven, escape

The grosser eye of man; for if the worlds
In world enclosed should on his senses burst,
From cates ambrosial, and the nectar'd bowl,
He would abhorrent turn; and in dead night,
When silence sleeps o'er all, be stunned with noise." *

* Thomson's Seasons—Summer.

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ON

MEDICAL ELECTRICITY,

CONTAINING

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PHYSICIAN TO THE LONDON HOSPITAL,
EXAMINER IN MATERIA MEDICA AND PHARMACY TO THE
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INTRODUCTORY REMARKS.

In the following pages, the author of this little treatise proposes to lay before the reader the present state of our knowledge respecting Electricity as a remedial agent. From various causes, Electricity, as a medical agent, has not yet had a full and fair trial, such as to enable the practitioner at once to predict whether in any proposed case it will be a sanative or inert application. In the early history of Electrical Science, it was anticipated, that, from its powerful influence on the human frame, it would prove a valuable auxiliary in the healing art; nor were there wanting those who were sanguine enough to regard it as an universal medicine, which might be resorted to in every form of disease. Philosophers had before them an agent of subtlety almost unexampled, which traversed the animal frame with unmeasured and irresistible activity—which affected the nervous and muscular system in a manner which it was beyond the power of volition to controul; and it was neither absurd nor unreasonable to suppose that such an agent might, under some modification, produce a salutary effect upon the diseases to which mortality is heir. But unfortunately, the progress of the science was arrested by the extravagant assertions promulgated relative to its success. Charlatans of every degree found the electrical machine a lucrative article of trade; and there were not wanting well-meaning enthusiasts, who contributed to prolong the reign of Medical Electricity. The more sober part of the medical profession on the other hand, finding the utter fallacy of many of these assertions—ascertaining that many of the experiments which had been published were

utterly without foundation—and disgusted with the vauntings of empirical professors and itinerant charlatans—fell into the opposite extreme, and set their faces utterly against the application of Electricity as a medical agent.

From such causes as these, the scientific application of Electricity to medicine has made less progress than the success which has really, in many cases, attended its use, might have been justly expected to produce. It appears, from every trial of its power hitherto made, that, under judicious management, its application has never been known to produce consequences decidedly injurious, while in many of the most distressing disorders, it has frequently been of considerable service. These are powerful recommendations; and when it is added that it is an external and by no means painful remedy, and that it may be applied immediately to the affected part, without interfering with any other organ, its advantages must appear to be considerable. At the same time it must be remembered, that it is a remedy of such a nature, that a long continuance of its application is in most cases necessary; and it therefore becomes desirable that ample instructions should be given to enable any one to apply it, under its different modifications, with security and ease. The avocations of the medical practitioner, and the constant attention to his professional duties required of him, preclude the possibility of his searching amidst the pages of the various scientific journals for a knowledge of its successes, failures, or mode of application; and it is to obviate such a necessity, and to induce the profession generally to make trial of its efficacy, that the author has endeavoured to collect, in the following pages, those cases of disease which, upon creditable authority, have been relieved by the application of Electricity in some one of its forms. A portion of the treatise has been devoted to a detailed description of those instruments which are requisite for its administration, and their management.

A TREATISE

ON

MEDICAL ELECTRICITY.

Chapter I.

HISTORY OF MEDICAL ELECTRICITY.

They who first proposed the medical application of Electricity, seemed to have entertained mistaken notions of the mode of its action, and, consequently, to have erred in their calculation of the effects which it was expected to produce. They conceived that it was to operate as instantaneously upon disease, as it did upon the sensations or muscular powers of the animal frame, forgetting that there are very few cases in which a system of depraved vital action can instantaneously be changed into a healthy discharge of the functions of life.

The first application of Electricity as an agent for the relief of disease, must have been subsequent to the discovery of the Leyden vial in the year 1745. The shock occasioned by this instrument appeared at that period so tremendous, that the most absurd accounts were related of it. Muschenbroek, in writing to Reaumur on the subject, asserted that he would not receive another such shock for the whole kingdom of France. The impression was such, that respiration was affected, and two days afterwards he had scarcely recovered from the emotion and inconvenience. M. Allamand, on taking a shock, declared "that he lost the use of his breath for some minutes, and then felt so intense a pain along his right arm, that he feared per-

manent injury from it." Winkler stated that the first time he underwent the experiment, " he suffered great convulsions through his body; that it put his blood into agitation; that he feared an ardent fever, and was obliged to have recourse to cooling medicines."

Nollet was the first who directly applied Electricity for the relief of disease. He had observed that its continued action on liquids accelerated their evaporation; and that this evaporation was far more considerable when the vessels which contained them had a larger opening, and were formed of good electrical conductors. Boze at the same time observed that electrified water issued from capillary tubes in the form of rays, in lieu of by drops. These two experiments were regarded as fundamental ones by those physicians who directed their attention to the application of Electricity as a medical agent.

In the year 1747, Johannes Pivati published at Venice the first of a series of errors and deceptions (whether intentional or not) which required much labour, and numerous elaborate experiments, entirely to disprove. He enclosed a quantity of Balsam of Peru in a glass cylinder, so that before its excitation no smell could be emitted. With this cylinder he electrified a man having a pain in his side. The patient returned home, fell asleep, and perspired; so effectually, we are told, had the virtue of the Balsam been thus conveyed to the patient, that his clothes and his hair were impregnated with the balsamic effluvium. In another experiment, a similar effect was produced upon a person in health, who was not made acquainted with Pivati's intention, and in whom the odoriferous emanation became perceptible to himself and others half an hour afterwards. Pivati next began to apply these powers to medical purposes: he professed to have cured, or rather discussed, an abscess in the foot of a young gentleman by electrifying him with a glass cylinder filled with certain drugs. His next patient was Signor Donadoni, Bishop of Sebenico, seventy-five years old, and greatly afflicted with the gout. The joints of his fingers had become fixed, and he had lost the power of bending his knees. Pivati tells us, that he proceeded to the cure by filling a glass

tube with discutient medicines, and so managing that the electric virtue might enter into the patient. The Bishop presently felt some unusual sensations in his fingers, and "in two minutes his lordship opened and shut his hands, gave a hearty squeeze to one of his attendants, got up, walked, smote his hands together, helped himself to a chair, and sat down wondering at his own strength, and hardly knowing whether it was not a dream. At length he walked out of the chamber, down stairs, without any assistance, and with all the alacrity of a young man." This and another similar cure, said to have been performed upon an old lady of sixty-one, may well account for the sensation that these experiments seem to have occasioned. The English and French physicians of that day attempted to verify these experiments of Pivati, which Winkler, a celebrated electrician of the period, professed to have repeated and found correct. In this attempt, however, they completely failed; and, after receiving from Winkler some tubes properly prepared, these also were submitted to a fair trial, and the conclusion at which they arrived was, that Electricity had no effect in forcing odoriferous effluvia through the substance of glass vessels. The zeal of the Abbé Nollet even carried him into Italy, that he might witness these wonderful performances for himself; but he also came back convinced that the odours were not transmitted through the glass, and that the enclosed drugs had no medicinal effect, although in certain cases of paralysis, &c. the Electricity itself was clearly beneficial. Dr. Bianchini also, of Venice, published an elaborate refutation of these fallacious experiments. To the clearly ascertained fallacy of these experiments of Pivati, and the absurd boasts of electrical empirics, of which mention has already been made, must be attributed the general apathy of more sober-minded practitioners, with regard to the use of Medical Electricity, which, like many other sciences, has suffered more from the extravagant eulogium of friends, than from all the attacks of its avowed enemies.

The discovery of Galvani in the year 1791, and the subsequent invention of the Voltaic Pile again aroused the attention of physiologists to the apparent identity of electricity and nervous

action, and the possibility of applying this agent to the relief of disease. The physiological effects of Galvanism, which almost exclusively occupied the attention of philosophers previous to the discovery of the pile, were those in which contractions in the muscular parts of animals were exhibited. The source of that surprising power which called forth such sudden and forcible muscular contractions, as took place when the nerve and muscles of the limb of a frog were respectively in contact with different metals which were themselves made to communicate, either directly or by the intervention of other metals, was most anxiously sought after; and it was not till after a long period of laborious research, in which a prodigious number of experimentalists in every part of Europe engaged, and occasionally involved themselves in inextricable mazes of perplexity, that the identity of the Galvanic and the Electric agencies was recognized and finally established. The ardour and perseverance with which these experiments were carried on, may be gathered from the fact that many of the philosophers subjected themselves to no inconsiderable suffering for the purpose of thoroughly carrying out the enquiry. Humboldt, for example, informs us that, with a view of more precisely ascertaining the nature of the contractions produced by different metals, he purposely applied two blisters over the deltoid muscles in his own arms; he covered one of the wounds with a large silver medal, and the other with a plate of zinc, and by means of a zinc wire established a communication between the two metals: the result of the contact was not only a violent smarting sensation on the blistered surfaces, but an alternate contraction of the muscles of the shoulder and the neck. When the blistered surfaces had been exposed to the air for the space of half an hour, so as to have become covered with effused lymph, the effect of the Galvanic contact was much diminished; but when, under these circumstances, a few drops of an alkaline solution were poured on the coating of lymph, the sensibility was immediately restored, the pain became extremely violent, and the contractions were renewed and succeeded each other several times successively. Not

satisfied with these results, he wished to obtain proofs of the farther action of Galvanism on the actions of the blood-vessels. Having abraded the skin of the wrist, attended with the effusion of a small quantity of blood, at the part where the radial artery is extremely superficial, he laid on the wound a coating of zinc, touching it also with a silver coin. As long as the contact continued, he felt a tension which extended to the ends of his fingers, together with a shooting and tremulous sensation in the whole extent of the palm of the hand; this painful sensation became manifestly more intense, whenever the edge of the coin was brought in contact with the zinc, and the irritation likewise augmented the discharge of blood. The coagulation of the blood, however, intercepted the action and diminished the effect; Humboldt now took a scalpel, and having made a slight incision in the part, the Galvanic process, which he continued for several days successively, produced a very decided inflammation.

During this period, when so much attention was directed to physiological researches, attempts were likewise made to apply Galvanism to medicine. Creve proposed its application to distinguish real from apparent death or asphyxia: when the muscular fibres contract, it is a proof that irritation is not entirely destroyed, and under such circumstances, it would be utterly impossible to decide that the individual was really dead; but Humboldt, who experimented on the same subject, was inclined to believe that Galvanism, in these instances, might induce error, since the practitioner might decide that death had really taken place, in a case where, probably, there was but a more or less temporary want of irritability.

Many experiments were made at this time at the Ecole de Medicine, relative to the treatment of disease by Galvanism; the commission who drew up the account of these experiments came to the conclusion that, "the effects of Galvanism were more apparent and more powerful in the nerves and muscular system than ordinary electrical machines; that it gives rise to violent contractions, painful sensations of pricking and burning in those parts which a state of disease renders insensible to

strong shocks or mere sparks, and that the duration of this effect is such, that it would seem to authorize the hope of discovering in this remedy an efficacious excitant, likely to prove of no slight advantage in the treatment of diseases."

Grapen Gresser, a colleague of the celebrated Humboldt, published a work on the employment of Galvanism in the treatment of certain maladies; he asserted that Galvanism could not only prove of service for the distinguishing of nerves from other organs, and particularly from vessels, but even for the indication of the distribution of superficial nerves. The effects, according to this writer, vary with the nature of the poles in contact with the affected parts; if, for example, a plate of zinc and another of silver be taken and placed in contact with a blistered surface, the sore covered by the zinc will first cease to discharge, and will soon cicatrize. His experience led him to assert that Galvanism was frequently useful in paralysis of the extremities, as also in compression of the brain; in weakness of sight and gutta serena only due to the want of excitability in the optic nerve; in deafness, caused by nervous weakness; in hoarseness and aphonia; in paralysis of the sphincter ani and the muscles of the bladder. About the same time, Lebouvier Desmortiers proposed the use of Galvanism for the treatment of urinary calculi; a round very hard stone, weighing a grain, was completely dissolved in twenty-four hours.

In certain experiments made upon frogs, Nobili believed that he had discovered a remedy against tetanus and paralysis. He observed that the contractions in the limbs of a frog increased under the action of one kind of electrical current to such an extent, as to produce an artificial tetanus, while a contrary current completely did away with this effect: and in his Traite de l'Electricité, Becquerel remarks, relative to Nobili's experiment, "that these observations are in the highest degree important, and deserve more extended enquiry; for, if we can succeed in destroying at will tetanus, which has been brought on in the frog by art, we may entertain the hope of curing tetanus in man, a disease which inevitably proves fatal to the individual who suffers from it."

Marianini has published a means for the useful application of Electricity in the cure of some cases of paralysis and paraplegia. He recommends that through the affected member should be passed for many days and even for many weeks, not a continued current, but rapidly successive Voltaic discharges, at first feeble, but gradually increasing in power; and he assures his readers that he has succeeded in effecting many cures by this means.

Another individual, who has devoted much time to the study of Medical Galvanism, has taken advantage of the calorific effects of the Voltaic battery for the production of internal moxas. It is known, doubtless, to most of our readers, that the resistance offered to the Electrical current by some metals, is such as to produce the ignition of the metals; thus, for example, if a thin piece of platina wire be placed between the poles of a battery, it will become red or even white hot. The plan of the writer to whom allusion is made, Doctor Fabré Palaprat, is to introduce into the part which he wishes to cauterize a thin platinum wire, connected with one of the poles of a powerfully charged battery, while the other pole communicates with the surface of the body: the electric current, when sufficiently intense, renders the platinum wire red hot, and thus destroys the organic tissues in contact with it; at the end of a few days a slough forms, which is easily removed. It is needless to observe that such an operation must be performed with extreme circumspection.

In Italy, the medical application of Voltaic Electricity has been studied in another point of view, and as there appears much promise, in this theory, of arriving at certain general and definite results in the therapeutical employment of Electricity, we shall make no apology for speaking of it somewhat in detail.

Monsieur Orioli, one of the most distinguished philosophers of whom Italy can boast, has published some theoretical considerations concerning a new means of modifying the laws of vitality, by changing the electrical state of living parts. These considerations are based on theory alone, but as they are

not rejected by philosophers, it is for this reason that a resumé of his propositions is here subjoined. After having recalled to the recollection of his readers the fact that in inorganic chemistry, the influence of the electrical states of bodies produces changes in their chemical properties, he asserts that this effect ought equally to take place in organic chemistry, and that if living substances do not exhibit the same kind of affinity with dead bodies, this difference ought to be considered as dependent on the existence, in the former, of some peculiar electrical state, differing from that which exists independently of life. "In the present day," he adds, "the great majority of physiologists believe that, life must be considered as the result of an action of certain piles, artistically arranged, and continually acting in such a manner that every organ is an electrical apparatus, and that all these piles have a common and reciprocal relation, so that the instant life ceases, the electrical actions have no longer the power of reproduction.

In acknowledging the truth of these principles, such piles, set in action by some unknown cause, dependent on vitality, ought necessarily to produce a positive or negative polarity in organs where, apart from the Voltaic action, it would not exist; from this it must result that at these poles there must be secretions, excretions, and special modifications, which cease the instant that the electrical action is destroyed.

In the same manner that we have succeeded in destroying the action of the sea upon copper by rendering this metal electro-negative, ought we to be able to change the nature of secretions in animals, by reversing the polarity of the organs which furnish them. The stomach, for example, secretes acids; the positive state predominates. If this secretion is too abundant, we must increase the contrary electrical state; it will be the same with the kidneys, when the urine abounds in uric acid, and gives rise to stone. We should impart to them an electro-negative state. In the same way, chancre engenders a secretion which, according to Crawfort, turns syrup of violets green; chancre then proves that the negative polarity prevails, and we must accordingly give it a contrary state."

M. Orioli recommends, that before attempting to apply Electricity therapeutically, we should study the nature of the secretions produced, in order that we may be enabled to create in the secreting organ a proper electrical state for bringing about contrary effects. These secretions will be acid, alkaline or neutral. If they be acid or alkaline no difficulty will exist; if they are neutral we should apply to the affected part the pole of the battery opposed to that electrical state which belongs to the normal condition of this part.

He proposes for this purpose, to apply, in two convenient parts of the body previously denuded, after the method of Mansford, two discs, the one of zinc, the other of silver, connected to each other with a metallic wire, keeping them in their proper situations by convenient bandages, for days, weeks, and even months, and only cleaning them when absolutely necessary. According to this distinguished philosopher, this remedial agent may be employed in the interior of the bladder, by introducing a sound whose extremity only is a conductor, while the remainder is covered with an insulating coating. This sound might be connected with one pole of the voltaic apparatus, while the other should be made to communicate with the kidneys. "Perhaps," he adds, "by this means we may succeed in decomposing calculi much more easily than has hitherto been imagined."

If the observation of another experimentalist, which we have already quoted (page 14) be true, that the sore, corresponding to the negative pole, has always a tendency to cicatrize, it might be possible to apply this fact usefully to the cure of certain inveterate ulcers, by bringing them into contact occasionally with the negative pole of a battery."

In our own country, our knowledge of the effects of Electricity remedially, is chiefly due to Mr. Carpue, Dr. Wilson Phillips, Dr. Golding Bird, and others; but as we shall have occasion hereafter to speak of the results arrived at from their experimental researches, we do not deem it necessary in this place to say more in detail of them.

Chapter II.

PHYSIOLOGICAL EFFECTS OF ELECTRICITY AND GALVANISM—ANALOGY WITH NERVOUS INFLUENCE.

We come in the next place to consider the physiological effects of Electricity under its different forms;—and first of that modification we call Frictional or Static Electricity.

It has long been suspected, and indeed rendered almost certain by a variety of facts, that the electrical state of the atmosphere has an appreciable influence on the animal economy. The lower animals seem aware of an approaching thunder-storm, as would appear from the uneasiness which they manifest, the cries which they utter, and their running about in a state of alarm, in search of shelter.

> "Prone to the lowest vale, the aerial tribes
> Descend: the tempest-loving raven scarce
> Dares wing the dubious dusk. In rueful gaze
> The cattle stand, and on the scowling heavens
> Cast a deploring eye:"—

Many individuals also of the human species, particularly those labouring under certain chronic complaints, or who possess what may be called a great degree of mobility of the nervous system, experience at such times very peculiar sensations. Observations such as these, and many others of a similar description which might be quoted, demonstrate very completely that the animal machine is frequently sensibly affected by the electricity of the atmosphere; and there is even nothing improbable in the conjecture, which has often been hazarded, that the salubrity or insalubrity of particular districts and seasons, the existence and character of epidemic diseases, are in some way connected with, if not immediately dependent on, the same influence.

The effects of artificially produced Electricity on animals vary according to the mode of applying it. If the individual be insulated, and placed in connexion with the prime conductor of a

machine, the whole surface of the body becomes electro-positive, and the electricity is constantly and silently discharged from all pointed parts of the surface, as from the hairs, fingers, etc. This mode of administering electricity does not appear to be uniform on different individuals. In some, the pulse is at first quickened, in others, it is unchanged; while in some it is, after ten or fifteen minutes, reduced in frequency. Copious perspiration sometimes breaks out; but it is not unlikely that these different effects are in part referable to the influence of mental emotion.

The electrical spark occasions a sharp pungent painful sensation—redness, and sometimes a small circumscribed spot or wheal, which, however, generally quickly disappears. The spark received from substances resinously electrified differs, in some respects, from that which issues from surfaces vitreously charged. It is more pungent, and has a different shape, being shorter, and not so regular in form. As medicinal agents, however, they appear both to produce similar effects. A contrary opinion has indeed been maintained by some, who have represented resinous electricity as a sedative and vitreous as a stimulant. This theory, which is quite unsupported by facts, is not a modern invention. It originated in 1779, with Berthoton, of Montpellier, who resolved diseases into two classes—those which depended on an excess, and those which were the consequence of a deficiency of the electric fluid, and treated the former with resinous, the latter with vitreous electricity. It is not necessary to enter upon any formal refutation of an hypothesis so absurd.

The most violent form of electrical effect is the *shock*. If a charged Leyden jar be discharged through the body, which may readily be done by applying one hand to the external coating and the other to the knob, a sensation of an exceedingly distressing kind is experienced, which is usually and very appropriately denominated the *shock*. The distance to which the shock extends depends upon the magnitude of the coated surface, and upon the intensity of its electricity. Thus, with a certain charge, it is felt at the wrists; with a stronger at the elbows; and with a still stronger even across the chest. A dull kind of pain is usually felt at the joints, which is probably to be traced to the

resistance which the force experiences in passing from one bone to another. If the diaphragm form part of the circuit, it is immediately thrown into a temporary state of contraction. If a strong shock be passed through this muscle, the sudden contraction will act so violently on the air of the lungs as to occasion a loud and involuntary shout; while a small charge frequently occasions a violent fit of laughter; persons of great nervous sensibility being much more readily affected than others.

When a small charge is passed through the spine, it instantly deprives the individual of all muscular power, so that if he be standing at the time, he either sinks on his knees, or falls to the ground. Mr. Singer, a celebrated electrician, "once accidentally received a considerable charge from a battery through the head; the sensation was that of a violent but universal blow, followed by a transient loss of memory and indistinctness of vision, but no permanent injury ensued." In persons killed by lightning, red streaks are frequently observed on the skin. It is said that marks are often observed, indicating the passage of the electric fluid along the spine. The blood is usually fluid, and the muscles flaccid; though occasionally rigidity of muscles has been found. It has likewise been observed that the body undergoes, in such cases, rapid putrefaction.

From these facts it will be seen that electricity produces a paralysing effect when brought to bear upon the centre of the nervous system. But when transmitted to the muscles of a limb, the invariable consequence is their spasmodic contraction; and this is true even though the member be in a paralytic state. From some recent researches, it is highly probable that the muscles are not directly sensible to the stimulus of electricity, but that they are thrown into convulsive action by the electric fluid, merely because of its traversing the nerves by which they are supplied.

Physiological Effects of Galvanism.

The Galvanic current, when brought to act on the living body, is capable of producing three classes of effects, viz.:—

1. The production of peculiar sensations—
2. Of muscular contractions—

3. An influence over the organs of secretion. Upon these we will observe in succession.

And first, with reference to the production of certain sensations. Voltaic Electricity acts in a manner peculiar to itself on all the nerves of sensation. If a slip of zinc applied to the tip of the tongue, and a silver coin placed between the gum and upper lip be brought into contact, an acid taste is experienced, but if the position of the metals be reversed, the taste is then decidedly alkaline. In order to the production of these sensations, the tongue must be covered with some moisture, for, when perfectly dry, no such impressions are perceived. For this reason it has been suggested, and it is quite probable, that such sensation is owing not to any direct action of Galvanism upon the tongue, but to the decomposition of the salts of the saliva, and to the consequent developement of an acid and an alkali at the opposite poles. When this experiment is performed in the dark, a flash of light is perceived, which is observable not only on bringing the metals into contact, but also upon separating them from each other; and it is worthy of remark that the flash is most vivid when the zinc is in contact with the tongue. A more decided effect is produced by attaching to the eye-ball, beneath the eye-lid, a slip of tinfoil, placing a silver spoon in the mouth, and connecting it and the foil. The experiment succeeds also in the light, and whether the eye be open or shut; and at the instant of contact of the metals, the pupil is observed to diminish in size, just as when the eye from comparative darkness is suddenly exposed to the glare of sunshine. By affecting the auditory nerve, in like manner, a peculiar sound is excited.

Upon the pain produced by Galvanism it is unnecessary to dwell at any length. It is an invariable accompaniment of the sudden transmission through, or withdrawal from, the body, of a strong electric current. During the completion of the circuit also, a disagreeable sensation is experienced, which becomes extremely distressing if the part of the body at which the current enters, or from which it issues, be deprived of its cuticle, or if there be a sore or cut in its line of passage. Pain may even, indeed, be produced by a very feeble current.

Production of Muscular Contractions.—When any part of an animal, either still living or recently killed, is made to form part of a voltaic current, a shock is experienced, closely resembling that caused by a weakly-charged Leyden jar, and the intervening muscles are thrown into convulsive action. This effect is equally produced whether the current be applied to the motor nerves themselves, or to the central organs of the nervous system. Thus, if while the negative pole is touched by the fingers of one hand, the other be brought into contact with the positive end of a battery, a concussion will be felt in both hands, which will extend to the wrists, the elbows, or even the chest, according to the intensity of the developed electricities. And it is further to be remarked, that not only is this shock felt when the circuit is completed, but also at the instant when it is broken, while during the maintenance of the circuit, no such effect is perceived. In order, however, to the production of these phenomena, it is necessary that the circuit be completed or interrupted with rapidity; for if the electric current be gradually admitted into, or withdrawn from, the body of an animal, no spasms will ensue. This fact is interesting, and in a practical point of view should be borne in mind, as will be seen when we come to treat of the remedial application of Galvanism and Electro-Magnetism.

From the experiments of various physiologists, it would seem that the effect of the voltaic current is more powerful on the voluntary than on the involuntary muscles. The muscles of the animal body may, it is well known, be divided into three classes: —the voluntary, the involuntary, and those of a mixed character. The muscles which move the limbs are voluntary; the heart is an involuntary muscle; and the diaphragm may be cited as an organ of the mixed class. Now, upon all three the galvanic current exercises a similar power, that is, it stimulates them to convulsive action. The involuntary muscles are doubtless much less affected by it than those which are influenced by the will; and it has even been contended by some that they are entirely exempt from its influence. This opinion, however, has been most satisfactorily refuted by the experiments of Fowler,

Nysten, Humboldt, and other eminent physiologists; and it is therefore needless here to dwell on the matter.

Another curious fact connected with this interesting subject is, that to produce the convulsions of a muscle by this agent it is not necessary that the electric current should extend to it, or that it should be included in the circuit. It is quite sufficient that the circuit should be completed through the smallest portion of the nervous trunk which supplies the muscle. This fact is amply proved by the experiments made by Nobili.

From all the facts then that have been collected on the subject of muscular contraction caused by the application of Voltaic Electricity, the following conclusions may be deduced:—

1. The muscular fibre is sensible to the stimulus of Galvanism when applied directly to it.

2. When an electric current is suddenly transmitted through a nerve to a muscle, or in the inverse direction, the muscle is thrown into spasmodic action.

3. The same effect is produced upon suddenly interrupting the electric current, when moving in either of the directions just described.

4. Precisely similar results are obtained upon completing the circuit through a portion of the nervous trunk which is distributed to a muscle, and upon interrupting it after being completed.

5. The most powerful contractions are produced by transmitting the direct current.

6. The next in point of energy are those which occur upon interrupting the inverse current.

Influence over the Secretory Organs.—It was our celebrated countryman, Dr. Wollaston,* who published the earliest conjectures in reference to the influence of Galvanism upon the secreting organs. Reflecting upon the wonderful powers of decomposition and transfer which Davy had lately shewn that the pile was capable of exerting, and upon the fact of a distinct electric apparatus having been detected in certain fishes, it

* Philosophical Magazine, vol. xxxiii. p. 488.

occurred to this eminent philosopher that the products of secretion might be due to electricity of low intensity, and he even suggested the nature of the secretions, as to acidity or alkalinity, as a test of the species of electric fluid accumulated in each organ. Thus, the milk, the perspiration, the urine, as being all acid, should upon this principle be considered as proceeding from organs in an electro-positive state; while the bile and different serous secretions, as containing a free alkali, would argue an electro-negative state of the parts from which they are discharged. Matteucci has espoused this theory, and added the important observation, that the animal principles occurring in the several secreted fluids, abound in elements of corresponding electrical relations; or that in the acid, oxygen and azote, in the alkaline, carbon and hydrogen, are chiefly to be found. It will be seen, on reference to our first chapter, that the same theory has been promulgated in Italy by M. Orioli; and upon it, he has endeavoured to establish a method of correctly applying electricity for a restoration of these organs to a healthy action, when in a state of disease.

Dr. Wilson Philip, however, is unquestionably the individual who has espoused this theory with most zeal, and illustrated it with most success. Arguing, that as the Voltaic current excites the functions of the sensitive and motor nerves, it also may exercise a similar influence over those nerves which are distributed to the organs of secretion, Dr. Philip endeavoured to establish the truth of this opinion in the case of the gastric juice. He divided the nervi vagi in a rabbit, and found that the digestive process was stopped. The respiration was thus immediately rendered laborious, nausea and fruitless attempts to vomit supervened, and the animals finally died, apparently of suffocation. Upon opening their stomachs, the parsley with which they had been fed was found quite unaltered. The same experiment was then performed upon other rabbits, with this difference, that galvanic currents were sent to the stomach, by applying one of the poles of a small pile to a slip of tinfoil rolled round the lower ends of the divided nerves, and the other to a disc of silver laid upon the epigastrium. In all these cases dyspnæa and

tendency to vomit were wanting; and the animals being killed after the currents had been continued for twenty-six hours, the parsley was found perfectly digested, and the stomach of each exhaled the odour peculiar to this organ during digestion. From experiments such as these, very frequently repeated, and always with the same results, Dr. Philip concludes that the secretion of the gastric juice is under the control of the nervous influence, and that this latter is identical with, because it may be replaced by, the power developed by galvanic combinations. Dr. Philip, however, does not confine himself to this inference, which, if not rigorously established, would at least appear supported by plausible arguments; but goes to the extent of asserting, that "Galvanism is capable of performing all the functions of the nervous influence in the animal economy;" or, to use his own words, besides "combining the elementary parts of the blood in the formation of the secreted fluids, it conveys impressions to and from the sensorium, excites the muscular system, and produces an evolution of caloric from arterial blood."

But it is necessary to state, that the conclusions of Dr. Philip in reference to the gastric juice, and the alleged facts upon which he professes to found them, have not met with universal adoption. Messrs. Breschet, Milne Edwards, and Vavasseur have, from experiment, been led to believe that Galvanism acts merely as a stimulant upon the glands which secrete the gastric juice, and that similar effects may be produced by anything causing a mechanical irritation of the lower ends of the divided nerves. They moreover conceived that they had established the following propositions, viz:—That the simple section of the pneumo-gastric nerves retards, but does not entirely prevent the digestive process: That the excision of a portion of them almost completely suspends this function: That in both the preceding cases, digestion is restored by the transmission of electric currents along the nerves of the stomach.

In justice however to Dr. Philip, it should be mentioned that Mr. Cutler,* operating under the direction and with the assist-

* Med. Chir. Review, vol. iii. p. 589.

ance of Dr. Philip himself and Sir Benjamin Brodie, was not enabled, by any means of mechanical irritation, to produce those effects which are upon all hands admitted to follow upon the due application of the electric current.

From this subject, we now pass to the consideration of the

Analogy of Electricity with Nervous Influence.

From what we have previously said, it will be evident that a remarkable analogy exists between the Galvanic energy, and the nervous influence; the former of which may be made, as in the experiments of Dr. Philip, to supply the place of the latter. The investigations which have been made into the anatomical structure and the nature of the phenomena evinced by the gymnotus, torpedo, silurus, &c. clearly prove that the effects they produce, are not the result of a peculiar force evidenced by these fish, but is the common one of nervism, and the force which traverses all nerves may be electricity. This is a notion which has long been entertained by many of our ablest physiologists; for experiment shews us, that a current of electricity, sent along the different nerves, produces effects precisely analogous to those which are consequent upon the transit of the nervous force: if it be sent along motor nerves, muscular action is the result; along sensitive ones, we affect the sensation peculiar to that nerve. But it may be argued, that if we assume that the nervous force is electrical, because a current of electricity sent along the nerves will give rise to effects simulating the vital functions, we ought, upon the principle of action and reaction, to be able, during the natural performance of these functions, to detect a current of electricity. Many experiments have been made, for the purpose of ascertaining whether this is the case, and generally these experiments have been successful in their results; and not only in the lower animals, but in man have these researches been carried on. Later observers assert that the current of electricity is increased after spirituous drinks, but diminished as the body cools; in other words, it is in the ratio of the chemical changes of the respiration. Matteucci has observed a deviation of the galvano-

meter (an instrument adapted for the detection of slight currents of electricity) amounting to fifteen or twenty degrees, when the liver and stomach of a rabbit were connected with the ends of a galvanometer; an action, which was not due to the different chemical properties of the secretions, for it ceased with death; and more recently, Professor Zantideschi and Dr. Favio assert that, in all warm-blooded animals there are two Electro-Vital or Neuro-Electric currents; one external or cutaneous, which directs itself from the extremities to the cerebro-spinal axis, and the other, internal, going from the cerebro-spinal axis to the internal organs. These currents grow weaker in proportion as life ceases, or as pain is felt; while the convulsive or voluntary movements give a strong current, or increase the discharge.

Many other experiments which tend to confirm the identity of nervous force and electricity may be cited. Dr. Prevost, of Geneva, has succeeded in magnetizing very delicate soft iron needles by placing them near the nerves, and it is a well known fact that this property is communicated to soft iron or steel, by a current of electricity transmitted at right angles to it. Vausseur and Berandi have likewise succeeded in rendering needles magnetic, by passing them through the nerve of a living animal, while division of the cord, they say, destroys this property, but the inhalation of oxygen increases it. M. David also reports that he has seen a galvanometer deflected when its poles were inserted into the bared nerve of an animal, and it was made to move, and that there was no motion when the spinal cord was divided.

But supposing that we had never yet detected a current of electricity traversing the nerves during functional activity, we are not therefore to conclude that there is no traverse of an electric current. We should bear in mind the great effects which our weakest, and otherwise almost inappreciable currents, are capable of producing on the living muscle; and to detect a current of as weak tension as must be that of the nerves, we ought to possess galvanometers as delicate as living muscle. Matteucci, indeed, has lately made use of this, and the result is perfectly

satisfactory. By connecting a prepared leg of one frog with the nerve and external muscle of another, violent contractions ensued, and by connecting the interior of a series of frogs' legs with the exterior of the next, and so on, a battery was formed whose effects were very considerable. From all these facts there can scarcely remain much doubt on the matter. Dr. Watson, in his Lectures on Medicine, observes, "I incline to the opinion that the influence which originates in the grey matter, and is transmitted by the white, will be found at last to consist in, or be nearly allied to, electricity." And that most profound philosopher, Faraday, remarks, "that from the time it was shown that electricity could perform the functions of the nervous influence, he has no doubt of their very close relation; and they probably are the effects of one common cause." Sir John Herschel too says, that the present state of electrical science warrants the belief, that the brain and spinal marrow form an electrical organ which is spontaneously discharged along the nerves at brief intervals, when the tension of the electricity reaches a certain point.

Such are the arguments which have been adduced in favour of the identity of the Nervous and Electrical forces. But recently Matteucci has totally denied their analogy, and from his extensive researches on the subject, much weight should be attached to his opinion. It would be impossible within the limits of so small a work to present to the reader anything like a complete account of the experiments upon which his opinion is founded. We shall, therefore, content ourselves with briefly stating his views, referring the reader, who may be anxious to pursue the enquiry to the elaborate work of the philosopher to whom we allude.* Matteucci is of opinion, that although at a first view apparently identical, and that possibly the one is capable of giving rise to the other, the nervous and electrical forces differ as much from each other as any other forces of matter—light and heat for example; and that the analogy between the two former is but of the same nature as between heat, light, and electricity; nay,

* Traite des Phenomenes Electro-Physiques des Animaux—par C. Matteucci, Paris.

further, that as electricity is capable of exciting a nerve, and thus producing contraction and sensation; so heat, a chemical or mechanical action, can be made to produce the same effects, and that it would therefore be equally right to insist upon the identity of heat or chemical action with the nervous force. That there is an electric current produced in the muscles themselves, by the chemical changes which take place, the result of the functions of nutrition; that the nerves themselves are but conductors of the current developed in the muscles to which they are nearest; that throughout the whole of the nervous system there is an ethereal medium, which may have some particular arrangement in this system—as is admitted with respect to certain crystals. When the organic molecules of the nerve are deranged by some cause, the ether, or more correctly speaking, the nervous fluid, is thrown into a certain state of vibration, which acting on the brain, produces sensation—on the muscles, motion. This derangement or vibration may be produced by an electric current, by other stimulants, heat, chemical or mechanical action, in the same way that it is naturally produced by the will. That the electric current generated in the muscles, and always directed from the interior to the exterior of the muscles, in its influence on the nerves, only acts by putting into a state of vibration the particles of ether or the nervous fluid. Such are the two theories on this important question, which we leave without further remark to the reader, since it would be out of place in a work, whose object is more particularly to describe the curative effects of electricity, to enter into more extended detail.

Chapter III.

OF THE DISEASES IN WHICH MEDICAL ELECTRICITY MAY BE APPLIED WITH HOPES OF SUCCESS.

"The uses of Electricity," observes Dr. Pereira,* "are partly rational, partly empirical. When the indications are to excite a nerve of sensation or of motion, or to produce a temporary contraction of the musles, or to promote transpiration and secretion, its employment may be regarded as rational. But it is used sometimes beneficially, in several diseases in which these indications are by no means obvious. In such its *methodus operandi* is unknown, and its use may be regarded as empirical."

We will proceed then to speak seriatim of the diseases in which the application of Electricity has been attended with success. The therapeutic uses of Electricity in any of its forms may be classified in the following manner:—

1. To stimulate the Nerves of Sensation.

In cases of *Nervous Deafness,* the application of electricity frequently affords relief; and from the experience of Mr. Carpue,† about one out of five patients are permanently cured. If frictional electricity be employed, sparks are to be thrown on, (by means of the director described in the succeeding chapter, page 39) or drawn from the mastoid process, the parts around the meatus auditorius externus, or the bottom of the meatus. If preference be given to voltaic electricity or electro-magnetism, one pole of the battery or director of the coil is introduced into one ear, and the other into the opposite ear; the circuit is then to be rapidly broken and completed a number of times.

Amaurosis. (Dimness of Sight.)—In this disease, the aura and sometimes slight sparks and shocks have been tried. It would appear that the prospects of success depend principally, if not entirely, upon the time the disease has existed. Mr. Hey pub-

* Elements of Materia Medica, vol. i.

† Carpue's Medical Electricity. Lond. 1803.

lished several successful cases of the use of Electricity in Amaurosis.* He never saw the least benefit when the disease had existed for two years. Voltaic Electricity has also been employed in this disease, when other remedies have failed; and, indeed, it will be obvious that this modification of electricity may be more readily transmitted through the ball of the eye, so as to traverse the retina, or be confined to those twigs of the first branch of the fifth pair of nerves which ramify on the forehead above the orbit, and upon the state of which alone, Majendie has shown that *gutta serena* often depends. It must, however, be employed with great caution, as its mechanical effect is calculated in many cases, to aggravate the malady.

Aphonia. (Loss of Voice.)—In some few cases, the application of Voltaic Electricity in this affection has been attended with success. The circuit may be completed through the organs chiefly concerned in the production of the voice, by placing a shilling upon the tongue, and touching it with the negative wire of a battery, whose other pole is alternately brought in connection with and separated from different parts of the external larynx—a method successfully employed by Mr. Miles Partington, in a case detailed in the London Medical and Physical Journal.

2. To stimulate the Motor Nerves.

The first disease of this class of affections which we shall notice is *Paralysis;* and there can be no doubt that electricity has been of considerable service in many cases of this kind. But it is necessary, before attempting the application of electricity, for the practitioner to assure himself of the real nature of the disease. If it depend on some lesion of the cerebro-spinal centre, relief by electricity is not to be expected. It is only calculated to be of service when the malady arises from some functional disorder of the nerves. In cases where the use of the parts was originally paralysed by effusion in some portion of the cerebro-spinal centre, and there is reason to believe that the blood effused has been absorbed, and that the paralysis remains from desuetude only,

* Medical Observ. and Inq. vol. v. p. 1.

stimulating the motor nerves by electricity is likely to be serviceable. There are several curious cases on record, with regard to the effect of electricity in Palsy. In the Haerlem Transactions, a case is recorded in which a hemiplegic patient recovered the use of his side after a hundred strokes from the gymnotus electricus, or electric eel; and in the Medico-Chirurgical Review, the following curious but well-authenticated anecdote occurs. A vessel on the Atlantic was struck several times by lightning, insomuch that many of the crew were strongly electrified. Among the passengers was a man who had been paralysed in both his inferior limbs for three years; at the time of the electric discharge he lay on his bed, but soon after perceived the return of power to his limbs, and was enabled to rise with the perfect use of them. The cure in this case was permanent.

But though it is generally admitted that electricity is occasionally a successful remedy in Palsy, still the remarks we have made above must ever be borne in mind; for in those palsies which depend upon compression of the brain, the application of so powerful a stimulant is likely to increase the evil we seek to remedy, especially when it is so employed as to act upon the vessels of the head. Applied as a topical remedy it will be less apt to produce mischief; and for this purpose the operation of electro-puncture, presently to be described, may sometimes be resorted to with advantage. The facility afforded of gradually increasing the force of the shock by the employment of the galvanic apparatus, renders galvanism a more safe and suitable arrangement than electricity; and according to the conclusions of Dr. Bardsley, its efficiency is superior to that of electricity.

The researches of Matteucci, to which, allusion has been already made, have thrown much light on the use of voltaic electricity in paralysis, and from the work before cited, we quote his remarks on its therapeutical application:—

"These are then facts, which independently of theory, or of all hypothesis on the nature of nervous force, may guide us in the therapeutical application of the electric current in paralysis. In fact, we may admit that in some forms of paralysis, the nerves of the affected limb are altered in some way similar to that which

would be produced by a continued passage of the electric current. We have seen that to reimpart it to a nerve, which has, by the passage of an electric current, lost its excitability; it is necessary to act upon it by a current made to traverse it in an opposite direction. In the same way, to cure the paralysis, we should pass a current of electricity through it, in an opposite direction to that which would have produced it. From this it will be seen that we are supposing that the paralysis we are about to submit to electrical treatment is either of the nerves of motion or of sensation. Thus, for a paralysis of a nerve of motion, the inverse current should be applied; while for a nerve of sensation, the direct current should be had recourse to. In cases of complete paralysis there is no reason for selecting one in preference to another. There is still another rule for its application, which theory has taught us—it is, never to continue the application of the current for too long a period, lest we should augment the malady which we wish to cure. The time for the application of the current should be shorter in proportion, as the current itself is more intense. Theory has taught us the necessity of applying the electrical current, varying the intensity according to the extent of the disease, for two or three minutes, at intervals of a few seconds. After these two or three minutes, during which time twenty to thirty shocks should be given, the patient should be left at rest some little time, after which the treatment may be renewed."

The cases of cure, which are recorded by Matteucci, prove incontestably the necessity for perseverance ere we can hope for successful results. Marianini in some cases continued the application of the voltaic current for some months; in two cases the cure was not effected till two thousand five hundred shocks had been passed through the paralysed limb; and Matteucci adds a case, in which both inferior extremities were paralysed; but where, after a continued electrical treatment, their use was perfectly restored. "These results," he adds, "although far from numerous, are sufficient to induce physicians seriously to study electro-physiological phenomena, in order that we may be able scientifically to adopt some therapeutical method of combating

a disease which unfortunately too often resists all the efforts of the physicians."

Tetanus.—In our introductory chapter, we have already made mention of some experiments of Nobili, from which that philosopher was induced to believe that voltaic electricity might prove a remedy in tetanus. Matteucci has confirmed this opinion; to describe the experiments on which his opinion is founded, we must again have recourse to his own words. "All narcotic poisons, such as opium and nux vomica, administered to frogs, first stupify, then excite them, and some little time before death they are seized with very violent tetanic convulsions. If in animals in this last stage we pass a current of electricity of a certain intensity, we observe the stiffness of the limbs disappear, and the convulsions cease. These frogs died after a certain time, but without exhibiting any symptoms of tetanus. In order to render the contraction which takes place at the commencement of the application of the current less powerful, it is better to employ the inverse current." A case of tetanus is related, in which an opportunity was afforded of trying the effects of this agent. The patient, during the time he was submitted to the electric treatment did not suffer from such violent convulsions—he could open and shut his mouth, circulation and secretion appeared to be re-established. Unfortunately these symptoms of amelioration were but temporary. "I dare not hope," adds the author, "that the application of the electrical current will invariably bring about the cure of tetanus; but I believe the opinion to be well founded, that during the passage of the electric current along the limbs of a patient attacked with tetanus, his sufferings may be at least in a great measure relieved."

Asphyxia. (Suspended Animation.)—In all cases of asphyxia, whether proceeding from strangulation, drowning, narcotic poisons, the inhalation of noxious gases, or simple concussion of the cerebral system, the use of galvanic electricity may be resorted to with hopes of success, care being, however, taken not to neglect other modes of resuscitation. In all such cases, the inter-

rupted current should be resorted to; the battery should be pretty powerful, and care should be taken that the electricity should be confined as much as possible to the nerves, and that it be sent along them in the direction of their ramifications. The chief object in asphyxia being to restore the circulation of the blood and the respiratory movements, the galvanic influence should be principally directed to the organs upon whose actions these depend; and towards accomplishing this, no plan appears more likely to be efficacious than that which has been recommended by Dr. Ure, and which we have described at full in the fifth chapter. We allude to the transmission of the current along the par vagum.

In asphyxia produced by concussion of the brain, there are strong reasons for believing that galvanism would prove extremely successful. This plan of treatment was first proposed by M. Goudret,* who had his attention particularly called to the subject by witnessing the death of an individual in the Ukraine, who had fallen on his head from his horse, notwithstanding the sedulous application of all the analeptic means familiar to the physician. Upon his return to Paris, he undertook an experimental enquiry into the efficacy of the pile in such cases, and found his expectations more than verified. In his first experiment, a rabbit which had been to all appearance killed by a few violent blows inflicted with the back of the hand, was perfectly recovered by a succession of shocks continued for half an hour, transmitted between the eyes, nose, and meatus auditorius externus on the one hand, and different parts of the spine of the animal on the other. In a second trial, made with a stronger rabbit, the method just described did not produce the desired effect within the space of thirty minutes; but upon removing the cuticle from the spine by caustic ammonia, and then applying the pile as before, at the end of the second half-hour the animal was restored to life, though it continued paralytic for a few days in its hinder extremities. Similar experiments have been performed by Dr. Apjohn with like success.

* Journal de Physiologie, vol. iv. p. 332.

In asphyxia by drowning, it is a remedy which should be resorted to. In a note appended to the communication of M. Goudret, above referred to, Majendie states that he, Pauillet, and Roulin had repeatedly succeeded in recovering, by means of the pile, rabbits axphyxiated by submersion in water for more than a quarter of an hour; and adds the important remark, that patience on the part of the operator is indispensable, inasmuch as in cases finally successful, reanimation was not often achieved for full thirty minutes. These results forcibly illustrate the value of Galvanism in the treatment of persons recently drowned; and it would appear advisable, according to the recommendation of Dr. Ure, that a Voltaic battery should be included amongst the means of resuscitation provided by the Humane Society.

In asphyxia from irrespirable gases, and poisoning by narcotic drugs, there can be little doubt that the pile would prove equally useful as a stimulant. Experiments performed upon the lower animals justify this conclusion, though galvanism is not usually mentioned by toxicologists amongst the means to be resorted to.

In sanguineous apoplexy, Dr. Wilson Philip suggests that galvanism might be used to enable the "lungs to perform their functions for a longer time than without this aid," and that thus the life of the patient might be prolonged.

In *Chronic Rheumatism*, there are very many instances of success attending the application of electricity. In the work of Mr. Carpue, already cited, a great number of such cases are recorded. The usual application is by sparks for ten or fifteen minutes every day. In recent cases, a few days sometimes suffice, but in those of long standing, very considerable perseverance is often required. The operation of electro-puncturation has been often employed successfully in such cases. While speaking of this operation, it may be well to observe that, from the the reports of its application in the Hospital St. Louis, by Cloquet, it would appear to be a most powerful means of combating morbid action. The diseases in which it has been found efficacious are, the different forms of rheumatism and neuralgia (in the latter affection, the needles should be

inserted in the course of the principal nerve, and the galvanic current transmitted in the direction of its ramification) next in spasmodic affections, as muscular spasm, hysteria, and traumatic trismus; convulsive hiccup and vomiting; periodic epilepsy, preceded by pain in the mammæ; and lastly, in inflammatory attacks, such as contusions attended with extravasation and great pain upon motion, opthalmia, pleurisy, carditis, and even erysipelas. It has also been used with success, in promoting the absorption of the fluid in ascites; and Carraro has proposed it for the treatment of asphyxia. In paralysis, it is admitted to be of little use, except for relieving the pain, which is frequently the most distressing accompaniment of such disease. Mr. Bourgeois has also proposed electro-puncture of the heart, to promote resuscitation in asphyxia. Admitting the efficacy of electro-puncturation in all these complaints, it is very difficult to form any plausible hypothesis as to the manner in which it acts: some theories have indeed been hazarded on the subject; they are however so vague, contradictory and unsatisfactory, that it would be a complete loss of time to enter upon an examination of them.

In *Stiffness* and *Rigidity* after sprains and bruises, when all inflammation and tenderness have subsided, electricity, in the form of sparks and shocks, has also been applied with success; it usually however, requires some perseverance to complete the cure. In *contractions*, depending upon the affection of a nerve only, electricity may prove of service. According to the experience of Dr. Carpue, electricity has been in many such cases employed without effect, while in others of long duration, immediate relief has been obtained.

In *Chorea, (St. Vitus' Dance)* and some other similar disorders, the employment of Electricity, in the form of friction or slight shocks in the course of the spine and limbs, is frequently attended with marked benefit, and we have the authority of Drs. Addison,* Pereira,† and Golding Bird,‡ as to its beneficial tendency.

* Guy's Hospital Reports, vol. ii. p. 493.

† Elements of Materia Medica, vol. i. p. 40.

‡ Guy's Hospital Reports, vol. vi. p. 14.

3. To promote Secretion.

In *Amenorrhœa*, considerable benefit is obtained by passing shocks through the pelvis, from the sacrum to the pubis. Dr. Pereira states that he has, in many cases, found the practice successful. In the "Dictionnaire des Sciences Medicales," there are recorded two cases of this nature. In the former of these, the patient was seventeen years of age, and had been suffering for eighteen months; she was also subject to spasms, which attacked her periodically. Menstruation was restored after the fourth application of electricity, and for two years afterwards remained perfectly regular, at the end of which time she married. The second case was that of a patient only fifteen years old. She was electrified for six months, at the end of which time, menstruation was restored. From the length of time, however, which elapsed, it appears doubtful whether her restoration to health is to be attributed to electricity.

Electric friction or slight shocks have also been proposed for the promotion of *biliary action*, but there are at present no authenticated cases of its efficacy.

4. To promote Absorption.

In *Indolent Tumours*, electricity is often employed in the form of sparks, slight shocks and friction. Mr. Carpue states that he has met with many cases which have thus been relieved. The most numerous cases recorded by him, are those of schirrous testes, and he relates some instances of the successful dispersion of schirrous indurations of the breast. He adds that ganglions have also been removed frequently from the wrists or feet, by the application of sparks. Dr. Pereira has tried electricity in several cases of enlarged cervical glands, without observing any benefit resulting therefrom.

Chilblains.—Mr. Carpue states that electricity is a good preventive against chilblains, and mentions two instances in which they were removed by the action of electric sparks.

Having thus enumerated those cases in which the application of both Common and Voltaic electricity may be applied to

produce relief, we shall conclude this chapter, by referring to the maladies in which Voltaic Electricity alone, is likely to prove advantageous.

In *Asthma* and *Dyspepsia.*—Galvanism, in the form of the continued current, has been strongly recommended by Dr. Wilson Philip for the treatment of indigestion, and what he calls habitual Asthma, that is, simple difficulty of breathing, unaccompanied by pulmonary spasmodic action, or any tendency to thoracic action. This application of Voltaic Electricity suggested itself to him, from his having observed in the course of the experiments we have already related, that, after the excision of portions of the par vagum, a current of electricity not only restored the digestive process, but also removed the difficulty of breathing. He describes the benefit obtained, as greatly exceeding his expectations. His method is, to apply a disc of silver to the nape of the neck and another to the epigastric region, and then to press the positive wire of a galvanic battery against the former, and the negative wire against the latter; the circuit is to be maintained until decided relief is experienced, which usually occurs within from five to fifteen minutes. In every instance, a suspension of the dyspnœa was thus effected, and in many cases the cure was permanent. The success which Dr. Philip experienced in his treatment of habitual asthma on this plan, led him to peculiar views respecting the pathology of the affection. The disease, he conceives, to consist in some impediment residing in the nerves, to the transmission from the brain of galvanic influence; and the artificial electric current he supposes to operate by removing such impediment.

Of the proposal to electrolyse *Urinary Calculi,* as also of the *Galvanic Moxa,* we have already spoken. Pravaz † has proposed to cauterize the bites inflicted by rabid animals by galvanic agency, and the principle on which he acts is as follows:—If the connecting wires of a common pile be made to touch a cut or ulcer, within a short distance of each other, the animal fluids undergo coagulation, and by properly shifting these wires, this

† Revue Medicale, Decembre, 1840.

effect may be extended to the entire surface. With a powerful battery, the effect resembles that which would be produced by a solution of nitrate of silver, containing about five grains of the salt to an ounce of water; and with a still more powerful battery, such for example, as ten pair of Grove's, the action is much more intense, and there is almost immediately formed an eschar of very considerable thickness. M. Pravaz details several cases in which this practice was resorted to in the cases of bites inflicted by rabid animals, in one of which, the cauterization was not had recourse to until fifty-four hours after the reception of the bite: the eschar was usually detached on the eleventh day, and the cicatrization completed on the seventeenth.

To coagulate the blood within an Aneurismal Tumour.—On the same principle as the former application of Galvanic Electricity, viz.—the coagulation of the animal fluids which contain albumen, it has been suggested, that Galvanism might be applied to the important purpose of coagulating the blood within an aneurismal tumour, and thus removing the disease, without resorting to the ligature. For this purpose, two needles are to be introduced into the tumour, and their projecting extremities connected with the poles of a Galvanic battery. Although this proposition is ingenious, we are not aware of its having been resorted to.

There have been many other propositions in connection with the therapeutic use of Voltaic Electricity. Indeed, there is scarcely a disease, or form of disease, in which some attempt to produce relief by Galvanism has not been made; and it is this empirical use of the remedy which contributes, to a great extent, to throw discredit on an agent which both has and will effect much good. We have, however, confined ourselves in this and the preceding chapters, to those cases where, either from theory we should be disposed to conceive that benefit might result from its use, or where success has really attended its exhibition. To have related the cases themselves would have been impossible within the limits we have prescribed to ourselves; and we have therefore been content to subjoin references to those works in which they were originally reported.

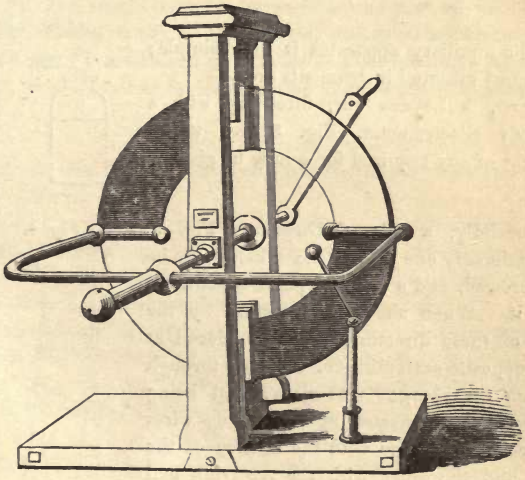
Chapter IV.

APPLICATION OF FRICTIONAL ELECTRICITY.—APPARATUS REQUIRED, AND METHOD OF USE.

It would indeed be a work of supererogation to enter into a minute detail of the form and appearance of instruments so well known as the Electrical Machine and its appendages. We shall therefore simply confine ourselves to a few remarks concerning the apparatus most adapted for medical purposes.

The machines employed for medical purposes should have sufficient power to furnish a constant stream of strong sparks; for in many cases, as will presently be seen, an application of that kind is essential. If it be a Plate Machine, as represented Fig. 1, the diameter of the plate should not be less than from

Fig. 1.



18 inches to 2 feet; if it be a cylinder, Fig. 2, the diameter may be from 8 to 14 inches.

Fig. 2.

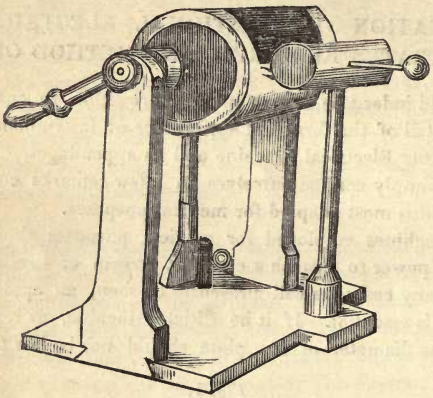
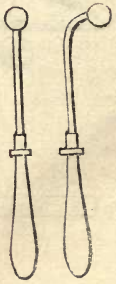


Fig. 3.

The auxiliary apparatus is very simple; the most essential instruments are,—

First, a Leyden Jar, fitted up with a Lane's Electrometer, Fig. 3, by which shocks of any required force may be given.

Fig. 4.



Secondly, a pair of Directors, Fig. 4. Occasionally one of the brass balls may be unscrewed, and a wooden point substituted for it. When shocks are applied by the aid of these directors, they are placed at the opposite extremities of the part through which the charge is to pass; and being respectively connected by conducting wires or chains, the one with the outside of the jar, and the other with the receiving ball

of the Lane's Electrometer, previously placed at the required distance, the jar may be set to the machine, which is then put in motion until any required number of shocks has been given.

The insulated director is employed also to give sparks, being held by its glass handle, and its ball previously connected with the conductor of the machine by a flexible wire, being brought near the patient, or rubbed lightly over a piece of flannel or woollen cloth, laid on the affected parts. When the eye or any delicate organ is electrified, the ball of the insulated director is unscrewed, and the wooden point applied at the distance of about half an inch from the part. The stream of electrified air, which passes from the point under such circumstances, produces rather a pleasant sensation. Very excellent flexible conductors for medical purposes, may be made by sewing a thin spiral brass wire (such as is used for braces) within a thick silk riband.

The insulating stool employed, should be of sufficient size to receive a chair upon it, with a resting-place in front of the chair for the feet. The patient being placed on the insulated chair, and connected with the conductor of the machine, becomes a part of it, and sparks may be drawn from any part of the body by a person who stands on the ground, and presents either his knuckle or a brass ball to it. If the ball be held by a wooden handle, the sensation is less painful than when it is held by metal.

As a remedial agent, Frictional Electricity may be employed in five different ways :—

The first of these is the *Electric Bath*. In this method the patient is placed upon the insulating stool in connection with the prime conductor, and the machine put in motion. His whole body becomes positively electrified, and the electricity continues to pass silently away. The Electric Bath was strongly recommended by Priestley, under the impression, still generally entertained, that the animal functions are, under such circumstances, discharged with increased vigour, particularly the circulation of the blood and the cutaneous secretion. Such effects are sometimes observed, but by no means invariably.

Electric Sparks.—The next and simplest method of applying electricity to the cure of diseases, is to present the member, or part affected, to the prime conductor of the machine, and thus cause it to receive a succession of sparks; or what is more convenient, to place the patient on a chair, and convey to him the sparks by means of a director connected with the conductor by a chain.

Insulation and Sparks.—The third mode consists in placing the patient upon an insulating stool, putting him in connection by means of a chain or metallic rod, with the prime conductor, and drawing sparks from the seat of disease or pain, by simply presenting to such part the knuckle, or should the operator prefer it, an insulated director connected by a chain with the ground. This method of operating has the advantage over the preceding, that it conjoins the electrical bath with the influence of the spark. It is therefore that usually adopted in the medicinal administration of electricity. The force of the spark is proportionate to its length; so that, by properly diminishing this, its strength may be reduced to any required standard.

A favourite method with some practitioners of applying sparks is to *give* or *draw* them across flannel. For this purpose a director, terminated by a large ball, which is to be covered with a fold of flannel, is approached in the usual way to the organ to be electrified. Instead of a single, strong spark, a series of weak ones will thus be produced, which, emanating at the same instant from several of the woollen fibres, extend over a considerable surface, and produce in it a peculiar pricking sensation. The ball of the director may be naked, the flannel being laid on the part of the body which is to be submitted to the influence of the sparks. This method is supposed to be particularly suited to the treatment of rheumatism and paralysis, especially in patients who cannot endure the stronger forms of electricity.

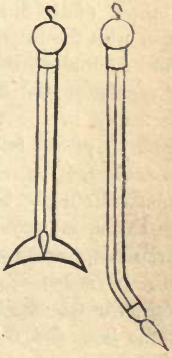
The Aura.—The next form of electricity to be noticed is the Aura, or jet of air which proceeds from an electrified point. This is the modification of the electric influence to which ulcers, excoriated surfaces, and delicate organs, such as the eye and

testicle, are usually subjected. The common method of employing the aura is to present a pointed director, connected by a chain with the conductor of the machine, and held by a glass handle, to the part affected. The particles of air in contact with the point are highly electrified, and immediately repelled. The same occurs to those which take their place, and so on in succession, producing a current of highly excited air, which is, as has been just described, directed upon the organ which is to be treated.

When the point which terminates the director is of baked wood, which, as is well known, is a bad conductor of the electric fluid, the electricity does not issue in a stream as in the former case, but as a succession of sparks, exceedingly minute, which produce in the part of the body upon which they are directed, a sensation perfectly similar to that which attends electrization across flannel. This kind of electricity is applicable to cases where the aura is not sufficiently energetic, and, where the sparks proceeding from a ball are found too pungent.

When it is required to apply electricity to deep-seated parts, such as the interior of the mouth, or the bottom of the external meatus of the ear, a particular form of director has been devised. It consists, as is shown in the accompanying diagrams, Fig. 5 and 6, of a glass tube of about one-tenth of an inch internal diameter, open at one end, and closed at the other by a cork, through which is made to slide a brass wire terminated within by a small ball. To apply this instrument, the open end of the tube is introduced into the cavity, and the internal extremity being brought as near to the affected part as may be deemed advisable, sparks, or the aura, are communicated in the usual way. The glass tube, from its non-conducting properties, prevents any lateral divergence of the electric fluid, and directs it upon the point placed immediately beneath its orifice.

Fig. 5. *Fig. 6.*



Shocks.—The last method of applying common electricity as a remedial agent, is by means of shocks. The method is simply to discharge a Leyden jar through the affected part or member, as may be considered advisable. The easiest method of accomplishing this is, to twist a thin wire round the exterior coating of the jar, and having charged it, to bring the wire in contact with one end of the course it is intended to traverse, and the brass knob of the jar to the other end. Against this method, however, the objection lies, that we are not enabled to measure the amount of the charge; to attain this object, it is necessary to interpose a discharging electrometer in the circuit. The knob of the jar being now placed in contact with the conductor of a machine in motion, and at the selected distance from one of the balls of the electrometer, the discharge takes place so soon as the free electricities have acquired sufficient tension to force their passage through this interval, and a shock is felt in the part of the body which completes the circuit. If this be too strong, the ball of the electrometer must be placed at a less distance, and vice versa. The two parts of the body between which it is intended that the electricity shall pass, are to be touched by the balls of two separate directors, held by an assistant, and connected by means of chains, the one with the electrometer, and the other with the outer surface of the jar. Thus, if one of the directors be in contact with the hip, and the other with the knee, when the discharge takes place, the shock will be felt along the entire thigh. The above described method of regulating the shock, should be familiar to such as employ electricity in the practice of medicine. The discharge of a small jar proves fatal to the smaller animals; and there can be no doubt that by means of a battery of no very great surface, human life might be destroyed. The power too, of sustaining the shock, is very different in different individuals, and even varies in the same person, so as to differ at different times and in different states of the system. These circumstances enjoin caution in the administration of electricity, particularly by means of the jar; and it may be added that its injudicious and indiscriminate use has proved extremely injurious.

"In the employment," remarks Dr. Apjohn,* "of electricity as a curative agent, there are certain precepts to be borne in mind, without an attention to which, disappointment will often be experienced, and unmerited discredit thrown upon a really efficacious means of subjugating morbid action." These may be reduced to the following heads:—

1. Electricity should only be considered as auxiliary to other modes of medical treatment, which experience has shewn to be advantageous. Thus, in rheumatism, it may be combined with diaphoretics; in chorea, with tonics; and in paralysis, with medicines which, like strychnia, stimulate the nervous system; a practice which has also been adopted for the cure of palsy, arising from the absorption of lead.

2. We should always commence with its weaker forms, such as the bath or aura; next proceed to sparks; and finally, should these prove insufficient, to shocks, taking care to regulate their strength by the means already described, and avoiding their exhibition when of such degrees of energy as to prove distressing to the feelings of the patient. The sparks applied in amaurosis, or for the discussion of glandular swellings, must be feeble, and in such cases, shocks are quite inadmissible. To communicate the latter, a jar, four inches in diameter and six in height, will be found amply sufficient.

3. The electrization should be performed daily, and be persevered in for at least a month, if necessary; and a cure must not be despaired of because there is no immediate relief experienced; for the good effects of electricity generally require a long time for being developed.

4. The *Aura* may be applied for from five to ten minutes. The number of shocks passed in one direction should not exceed twelve, nor the number of sparks twenty-four.

5. In local affections, the electric fluid should be confined to the diseased part or organ; but in diseases such as chorea and epilepsy, in which the entire system seems to be engaged, it must be applied generally over the body; such parts, however, as are affected with pain or any unusual sensation, should be particularly dwelt on.

* Cyclopædia of Practical Medicine, vol. i. art. Electricity.

Chapter V.

APPLICATION OF GALVANISM—BATTERIES AND THEIR USE—ELECTRO-MAGNETISM—MACHINES AND THEIR USE—MAGNETO-ELECTRICITY.

The discharges of a galvanic battery and a Leyden jar produce effects so analogous, as to render it probable that they affect the living body in the same way, and that they may, therefore, be indifferently applied as stimulants to the nervous system. The voltaic pile, however, possesses many advantages which do not belong to the electrical machine: the quantity of electricity it sets in motion is vastly greater, a peculiarity which may probably confer upon it a higher degree of medicinal power; there is no difficulty in bringing it into action in any kind of weather; the shocks it gives may be more exactly graduated, and admit of being directed with facility to organs which it is difficult, if not impossible, to subject to the influence of the common electric spark; as, for instance, in cases of deafness, gutta serena, amaurosis, and aphonia.

Whenever galvanism is intended to produce an exciting effect, is must be exhibited so as to produce shocks, or in the form of the interrupted current. In asphyxia, for example, the chief object is to restore the circulation of the blood and the respiratory movements. The plan adopted by Dr. Ure, and which has been found the most efficacious, consists in laying bare the sheath which encloses the *par vagum* and great sympathetic nerve, touching it with the wire connected with the positive pole of a battery, and while one extremity of the negative wire is pressed under the cartilage of the seventh rib, drawing the other along the upper edges of the plates of the trough towards its copper or silver end. This plan is very efficacious, and is much more readily arranged than any contact-breaking apparatus. In this way, a rapid succession of discharges, each succeeding one of which exceeds the preceding one in intensity, is sent to

the lungs, the heart, and the diaphragm, that is, to the organs whose functions we are anxious to revive. The same method of manipulation may be employed in all cases where the interrupted galvanic discharge is requisite, that is to say, where it is desirous to stimulate the nerves to increased action, and where, by the practitioner, it may not be deemed advisable to have recourse to the electro-magnetic coil machine, presently to be described.

Whenever galvanism then, is intended to produce an exciting effect, it must be exhibited so as to produce shocks, or in the form of the interrupted current. There are however, certain affections, in which it is conceived most beneficial when flowing in a continuous stream; the specific effects of it, when thus applied, being supposed of a sedative kind. This opinion of the difference of action of the voltaic pile, in the two conditions of it just described, does not rest upon mere conjecture; it is based upon the observations of medical electricians, and upon the experiments of Nobili and others which we have already detailed. It is generally thought that convulsive affections, not excluding tetanus itself, may probably admit of being controuled by galvanism; but that in these, the method of administration should be the opposite to that for paralysis; or that instead of the interrupted, the continued current should be resorted to; and that to obtain the maximum tranquillizing effect, the electricity should be transmitted along the nerves, in a direction contrary to that of their ramifications.

In the therapeutic administration of galvanism, the feelings of the patient must be our guide as to the strength of the charge which should be employed in each particular case; some will sustain with impunity the shocks of a battery which would prove most distressing and injurious to others; the dose may be graduated to any required degree of nicety, by properly varying the interval between the conducting wires, for upon this, with a given machine and exciting fluid, will depend the degree of energy of the developed electricities; the strength, in fact, of the galvanic shock, depends not so much upon the size, as upon the number of pairs which compose the battery; the power too of the batteries, will depend much upon the strength

of the acids employed, as will be seen in the subsequent part of this chapter. The wires used for completing the circuit, should be furnished with insulating handles composed of glass, and be armed at their free extremities with balls of brass, or what answers better, of silver, gold, or platina; should such be wanting, silver discs (shillings will answer the purpose well) should be laid upon the parts between which the current is to be made to pass, their position being occasionally changed, to prevent the skin beneath from being injured. The subjacent cuticle also, being a non-conductor, should be moistened with a solution of sal-ammoniac, common salt, or vinegar and water.

In concluding this part of our subject, we shall subjoin a recapitulation of the general principles of practice laid down by a celebrated modern writer, Dr. Apjohn.*

"1. Feeble powers should always be first tried; these should be gradually augmented, and the use of such finally persisted in, as, without producing any violent effects, appear to make a decided impression on the disease.

"2. Galvanism as a remedial agent, must not be hastily given up because of its beneficial effects not immediately appearing, for these, generally speaking, require considerable time to be developed.

"3. The pile should not be relied on exclusively in the treatment of diseases, but should rather be considered as auxiliary to other methods of cure.

"4. To the preceding we shall add, that in cases where the continuous current may be deemed most advisable, it would be well to resort to machines composed of plates having an extended surface, there being reason to believe that the curative influence of galvanism in this form, depends not upon its intensity, but upon the quantity of it set in motion."

To these principles we may add, that in all cases where it is necessary that the interrupted current should be administered, the electro-magnetic coil machine will be found much more manageable, much more portable, and equally powerful, if not

* Cyclopædia of Practical Medicine, vol. ii. art. Galvanism.

more so, than the galvanic battery itself. The various forms of this instrument will be described at the end of this chapter. In cases where the continuous current is required, the battery alone can be used.

Voltaic Batteries.

It will be seen from what has been said, that, for the due application of Galvanism as a remedial agent, it is essential to have a full understanding of the construction of Batteries and their manipulation.

The first of these instruments which we shall describe is that represented in Fig. 7, known as *Cruickshank's Battery*. It consists

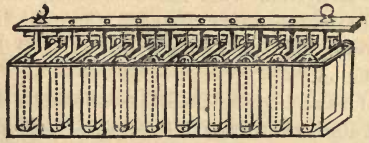
Fig. 7.

of a series of pairs of zinc and copper plates fixed into a trough of wood, and may be excited either by dilute sulphuric acid, or by a solution of sulphate of copper, which latter, as Dr. Fyfe* has shown, increases the electro-chemical intensity of the electric current. This form of apparatus is neither so convenient as, nor does it possess the power of, the modern arrangements which we shall presently describe; but as many such instruments are still in use, we have deemed it necessary to make mention of it. The battery of Dr. Babington is formed on the same principle as the preceding, with the exception that the plates of copper and zinc, usually about four inches square, are united together in pairs, by soldering at one point only, and are excited by immersion into a trough of earthenware, divided into ten or twelve equal portions, and filled with dilute sulphuric acid. In both these batteries the liquid should consist of about one part acid to fifteen or sixteen water. The plates are attached to a strip of wood, and so arranged that each pair

* London and Edinburgh Philosophical Magazine, vol. xi. page 145.

shall enclose a partition between them; by this means the whole set may be at once lifted into or from the cells; and thus while the fluid remains in the trough, the action of the plates may be suspended at pleasure. The form of this battery is represented in the annexed diagram, Fig. 8. A further im-

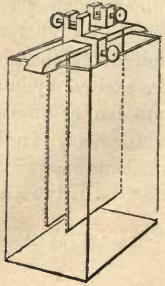
Fig. 8.



provement in this form of battery was made by Wollaston. It consists in doubling the copper plate, so as to oppose it to both surfaces of the zinc, while the contact of the surfaces is prevented by pieces of wood or cork placed between them. Ten or twelve troughs on this construction form an efficient Voltaic Battery.

Smee's Battery.—Of all the galvanic batteries, however, now in use, it will be found that the combination invented by Mr. Smee, usually known as Smee's Battery, is the most useful for medical purposes. It has the advantage of being tolerably constant, sufficiently powerful for all cases, portable, easily charged, and as easily cleaned. Its general plan is represented in Fig. 9. The battery consists of a plate of platinized silver, connected with a binding screw, and fixed to a beam of wood. A strip of stout and well amalgamated zinc is placed on each side of the wood, and both are held in their place by a binding screw, sufficiently wide to embrace the zinc and the wood. This arrangement is immersed in a cell containing diluted sulphuric acid, made by mixing together one part by measure of sulphuric acid and seven of water. The

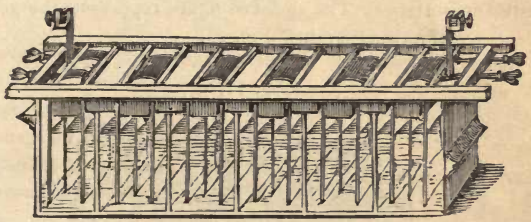
Fig. 9.



operator must be careful that the silver in no place touches the zinc. The arrangement thus immersed will be found to produce no effect on the liquid until a communication is made between the metals, when a violent evolution of hydrogen gas takes place, and an active voltaic battery is obtained. If, however, the zinc be imperfectly amalgamated, or from want of care in the immersion of the arrangement, the silver plate has any portion of its surface in connection with the zinc, an action is apparent. In the former case, it depends on the want of protection afforded by the coating of mercury to the zinc, and may be easily obviated by fresh amalgamation; in the latter it is still more easily remedied by examination, and the separation of the metals wherever they may be in contact. This form of battery is the one usually sold for medical purposes by the publishers of this work.

For intensity effects, Smee's Battery may be arranged as an ordinary Wollaston with advantage, as shown in Fig. 10. Ten or

Fig. 10.

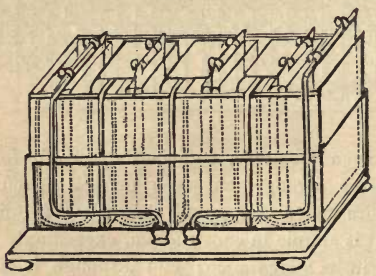


12 form an elegant battery, sufficiently powerful for all medical purposes. This arrangement is a general favourite, and is probably more extensively used than all the other forms put together. It is simple in construction, exceedingly manageable, and elegant in its appearance; and although it is not so constant as that invented by Professor Daniell, nor possessed of the intense energy of Professor Grove's, it has the great advantage of being almost instantaneously set in action, and as quickly cleaned and put aside. Hence its great utility for medical pur-

poses: added to which it may be remarked, that this form of battery gives rise to no unpleasant or noxious fumes, and this must be allowed to be a great desideratum.

Grove's Battery.—Another form of battery which may be employed is that of which we have already spoken, generally known as Grove's Nitric Acid Battery. It consists of a series of porcelain cells or jars, containing slips of amalgamated zinc, in contact with dilute sulphuric acid, of the same strength as that before recommended for the Smee's arrangement. In these jars are placed parallelopiped vessels, made of porous clay, containing strong nitric acid, into which are immersed slips of platinum foil; each slip of platinum is attached by a binding screw to the next zinc plate, so as to leave at the one end of the battery a zinc pole, at the other a platina pole. This arrangement is by far the most powerful voltaic apparatus yet known. The only disadvantage attending its use is the time required for charging it, which, in a case of emergency, such, for example, as asphyxia from drowning or any other cause, must be of the greatest importance. The annexed figure represents the general appearance of this apparatus. Fig. 11.

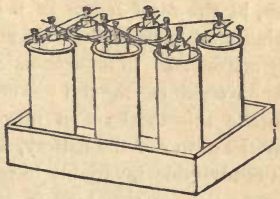
Fig. 11.



The last form of battery which we deem it necessary to describe, is that invented by the late Professor Daniell, and by him termed the *Constant Battery*, (Fig. 12) from its power of continuing

in action for a lengthened period of time. It consists of a cell of copper, which of itself forms the negative metal, containing a tube of porous earthenware of much smaller diameter. Within this porous tube is placed a rod of amalgamated zinc, to which, as also to the copper cell, is attached a binding screw. A cell of this description is excited in the following way :—the porous tube containing the zinc is filled with dilute sulphuric of the ordinary strength, and into the copper cell is poured a saturated solution of sulphate of copper, made by pouring boiling water upon a superabundance of the crystals of the salt of copper.—A perforated metal shelf is fitted to the top of the cell, for the support of a supply of crystals to recruit the exhausted strength of this battery.

Fig. 12.



Having thus described briefly, but we trust, intelligibly, the various Voltaic Instruments in use ; it may be requisite, before dismissing them completely from notice, to make a few remarks on some of the practical points attending their manipulation. In the first place, it is absolutely necessary that the various connections of batteries should be perfectly clean to insure a good metallic contact. If this point be neglected, it will frequently be found, that either the apparatus will not act at all, or at all events be much diminished in power. The interior of the binding screws, or the surfaces where the excited metals are, as in Grove's battery, placed in contact with each other—and the ends of the conducting wires should be perfectly freed from metallic oxides or dirt, by means of sand paper—a very little trouble being sufficient to effect this. The necessity of perfect

metallic contact being insured by the cleanliness of those portions of the apparatus which require to be in direct connection with each other cannot be too strictly enforced.

Amalgamation of the Zincs.—In the course of this chapter we have had frequent occasion to speak of the amalgamation of zinc, that is to say, the covering zinc with a coating of mercury, to prevent the rapid action which would otherwise take place between the liquid and the metal. For the proper and profitable use of these batteries, it is necessary that this amalgamation should be so perfect, that no action should be apparent until the circuit is completed. The zincs sold at the philosophical instrument makers are generally properly amalgamated; but after some little use, it will be found that the metal requires a fresh amalgamation, otherwise, by the *local action*, as it is usually termed by electricians, taking place betwen the acid and the metal, the zinc will be rapidly consumed. In an economical point of view, therefore, as well as for obtaining the full power of the battery—(for, however energetic this local action may be, it does not increase in any way the power of the battery, but has a directly contrary effect)—it is advisable invariably to re-amalgamate the zinc the moment any action of this kind is apparent. This is easily effected; it is only necessary to remove the zinc from the battery, rinse it in a little cold water, and to pour on it a few drops of mercury, which will immediately attach themselves to the zinc, and may be rubbed uniformly over its surface by means of a little pad of tow. It requires but little trouble to do this, and the result will in all cases be found amply to repay it.

While on this matter, it may be well to press upon the reader the necessity of invariably cleansing the battery before it is finally set aside. The acid solution should not be thrown away, as it will serve for many operations. It is not until any considerable quantity of sulphate of zinc is formed that the voltaic action is rendered less energetic. The plates should always be thoroughly rinsed in cold water, and set aside to drain. The platinas of Grove's battery should be thoroughly well washed, dried with blotting paper, and kept perfectly smooth until again

required for use. The zincs should, as in other batteries, be rinsed and set aside to drain. The detail of these minute points may appear tedious, but it will be found that attention to these matters will prevent disappointment, and the operator will be enabled to insure the proper action of his apparatus.

Of the terms POSITIVE *and* NEGATIVE.—There is nothing which has a greater tendency to confuse the mind, with regard to voltaic apparatus, than the terms *positive* and *negative* end of a battery. "The fundamental principle," observes Mr. Walker, "which cannot be too strongly enforced, is, that the passage of the electricity is from the zinc to the copper." This, of course, refers to the common forms of battery—Cruickshank's, Babington's, &c. In the arrangement of Smee, the passage of the electricity is from the zinc to the silver; in Grove's battery, from the zinc to the platinum. "The positive is the end where the electricity leaves the battery; the negative where it re-enters it. The direction taken by the current being ascertained by the mere inspection of the situations of the two metals in a cell, the other points follow as a necessary consequence." Now, taking the Smee's battery as an illustration, it must be clear, that as the electricity passes from the zinc to the silver, it would leave the battery by the wire attached to the silver plate, and having passed through the interposed apparatus, would return to the battery by the wire attached to the zinc plate; the silver, which is the *negative metal*, forming the *positive end* of the battery; and the zinc, the *positive metal*, forming the *negative end*. In like manner with all the batteries we have described, the zinc, though the *positive metal*, is the *negative pole*.

ELECTRIZERS.

There is another method which has been devised for the topical application of Voltaic Electricity, and which, from the name of their inventor, usually pass under the title of *Harrington's Electrizers*. They are plates of copper and zinc, or silver and zinc, made in different shapes. In tooth-ache, for

example, a plate of silver is soldered by its edge to a plate of zinc, and worn in the mouth, the saliva serving to excite the apparatus, and to produce a voltaic circuit. In another contrivance, a plate of zinc is connected by its face to a plate of silver; and a series of these compound plates are connected together by wire, so as to move on each other like hinges. These are worn next the skin for the relief of rheumatism, the perspiration serving to excite the plates. Silver and zinc spangles have likewise been employed, instead of the plates just mentioned.

Electro-Puncturation,

As it is usually denominated, is performed by inserting, in the ordinary manner, two or more needles into the part or organ affected, and then touching these with the wires from the poles of a feeble galvanic battery, the contact being occasionally suspended and renewed, so as to produce a succession of shocks. It has been chiefly employed by Cloquet, at the Hospital of St. Louis; and from the reports of his friends, Pelletan and Dantes, and from the treatise of the Chevalier Sarlandier, it would appear to be a most powerful means of combating morbid action. The diseases in which it has been successful have been enumerated in a preceding chapter (page 36.)

Electro-Magnetic Coils.

There yet remain for description in this chapter, the most recently invented and the most convenient instruments for the application of Galvanism, usually called Electro-Magnetic Coils. The limits to which we are compelled to confine ourselves, preclude us from entering minutely into the experiments and phenomena which led to their construction, and we shall therefore content ourselves with simply enumerating the principles on which their action depends, leaving the reader who may need

further information, to consult the excellent works of Mr. Noad,* or Mr. C. V. Walker,† on this subject.

If a copper wire be twisted in the form of a helix, and a current of electricity be passed through it, it *induces* another current of electricity in any other coil which is in its immediate vicinity. If a small bar of iron, or what is better a bundle of iron wires, be introduced into the axis of the helix, and a current of electricity be passed through the coil of wire, it will be found that the electric spark, and its accompanying snap, are much increased; but it is only on breaking contact with the battery that this effect is produced; the reason is that the iron, magnetised by the power of the continuing current, loses its magnetism at the moment the current ceases to pass, and in so doing tends to produce an electric current in the wire round it.

Mr. Callan, of Maynooth College, was the first who contrived a convenient apparatus for the illustration of secondary currents. A coil of thick insulated copper bell-wire is wound on a small bobbin; and on a large rod, with a hollow axis, in which the bobbin may be introduced at pleasure, a length of about 1500 feet of thin wire is wound; the two coils are thus perfectly distinct from each other, and by sending the current from the battery through the interior coil, the Electricity present in the exterior coil is set in motion by its inductive influence; and from it both physiological and electrolytic effects may be obtained. If 100 yards of fine insulated copper wire be wound on a reel, and contact with an electrometer rapidly broken, shocks may be obtained, by grasping metallic cylinders in connection with the ends of the coil, from the reflex wave of Electricity which is generated; and if a bundle of iron wires be placed in the axis of the helix, the brilliancy of the sparks, and the intensity of the shocks will be greatly increased, in consequence of the second wave of Electricity being, as we have seen, produced at the moment of the demagnetising of the iron.

It is on this latter principle that the greater number of the Electro-Magnetic Coils are constructed. There are many forms

* Lectures on Electricity, by Henry M. Noad. Lond. 1844.

† Second volume of Electricity in Lardner's Cabinet Cyclopædia.

of these instruments; but their principal difference consists in the means adopted for breaking the battery contact, and so giving rise to the secondary current. The form of apparatus which appears to us to be both simple and manageable, is that represented in the accompanying diagram.

Fig. 13.

Fig. 14.

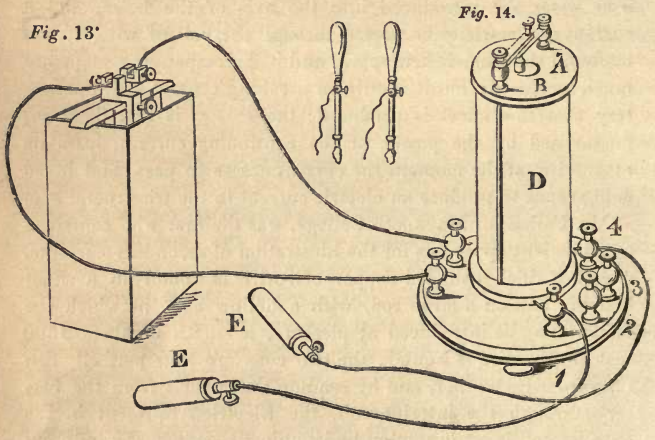


Fig. 14, D represents the Electro-magnetic coil, the construction of which will now be readily understood. It consists of two coils of insulated copper wire; the one internal, which, by means of the binding screws, can be connected with a Galvanic battery, as seen in the figure. This is called the *primary* coil. The other, or *secondary* coil, is placed externally, and is in connection with the four binding screws, marked respectively 1, 2, 3, and 4. In the centre of the primary coil is placed a bundle of fine iron wires, (seen at B,) for the purpose of increasing the intensity of the effect, as already explained. Fig. 13 is a Smee's battery, connected with the Electro-magnetic coil. The moment that battery contact is made, the electricity circulating through the bundle of iron wires renders them magnetic, and they immediately

attract a small piece of iron placed directly above them. This iron is attached to a spring, (A,) so contrived, that the attraction at once and completely cuts off contact with the battery. Two effects are thus produced. The circulation of the electric current through the primary coil gives rise by induction to a current of electricity in the secondary coil, which is also considerably increased by the reflex wave of electricity set in motion by the demagnetising of the iron wires. The electricity thus generated from these combined sources produces all the physiological effects required, giving rise to strong shocks. But the moment the iron is demagnetized, the spring A falls back to its place, and connection with the battery is again established, the wires are once again rendered magnetic, and the same effects follow; the rapidity, indeed, with which the instrument acts is almost incredible.

In the foregoing figure, E, E, are the directors, applicable for the mere transmission of shocks through the body generally; they are intended to be grasped in the hand of the patient. When, however, it is required to transmit the shocks through any affected limb, or to confine them to any organ, the sponge directors, represented above them in the same figure, must be resorted to. They consist of metallic tubes, fitted with insulating handles to protect the operator while administering the shocks. Into the extremities of the metallic tubes pieces of sponge are to be placed, and they are retained in their places by means of sliding rings, with which the tubes themselves are furnished. Close to the handles are binding screws, into which are to be fitted the conducting wires from the secondary coil of the machine. When required for use, the sponges are to be well moistened with some liquid, so as to increase the conducting power; vinegar and water is generally used, as being at hand. The sponge directors are equally applicable for the administration of Galvanic Electricity immediately from the battery.

In the management of the Electro-magnetic coil, it is necessary always to observe that the spring attached to the ball A touches the screw C; at the same time it must not be pressed down so tight as to cause the ball to touch the iron wires in the axis of the coil. According to the power required, the directors

must be fixed to the binding screws; thus, if attached to Nos. 4 and 3, the least power will be given; if to 4 and 1, the greatest. The power may be increased or diminished according to the size of the battery, and the strength of the acid used. These instruments are readily set in action; easily cleaned; very manageable; and as efficacious as any other form of Voltaic apparatus. To the medical practitioner, their portability is not their least recommendation, since they are sold in a neat packing-case, which contains the battery, directors, coil, and all necessary appendages.

We have said that there are other forms of this instrument; but as they differ (with one exception, the Galvano-Therapeuticon, hereafter described,) only in the mode of breaking the battery contact, we do not deem it necessary to occupy more space in details which, considering that the principles upon which they are constructed are essentially the same, would doubtless be considered tedious. We repeat, that all these machines act in the same way, and depend on the same philosophical principles for their action and efficacy. This is a fact which we are the more disposed to impress strongly on the mind of the medical reader, since we are aware that latterly there have emanated statements in direct opposition to this, from many unprincipled venders of such apparatus, actuated only by mercenary motives. Such groundless assertions are but a part of that spirit of charlatanism which arrests the progress of all great truths, or, with reference to new and important remedies, gives rise to incredulity on the part of those who discover the deceit.

GALVANO-THERAPEUTICON.

We now come to the latest and most approved arrangement for medical purposes, viz: the Galvano-Therapeuticon of Mr. Charles Brown, jun. of Woolwich.

This machine bids fair to be far more popular than any of its contemporaries. It is very *efficient, perfectly safe*, and *of such singular facility of management*, as to render it, in this respect,

incomparably superior to anything of the kind we have seen. The Galvanic current can be so regulated by a beautifully simple method, contrived by the inventor, that the most delicate persons receive it with expressions of approbation and pleasure; an advantage, the importance of which will be appreciated in no small degree by the medical practitioner and Galvanist. Another distinguishing characteristic of this machine is its compactness and elegant appearance, as will be seen by reference to the accompanying sketch.

As the Therapeuticon will speak for itself, its advantages being so obvious, we need say nothing farther to advance its superior claims, other than that, to the most distinguished patronage, is added the unqualified encomium of some of the first men in the scientific world, as the note (which we have taken the liberty to subjoin) from that eminent chemist, James Marsh, Esq. will suffice to shew:—

"My Dear Sir,

"I have taken much pains to examine the arrangement of the Therapeuticon, as proposed by your son, and have much pleasure in saying that, in my opinion, it is by far the best form of the apparatus I have yet seen. The method by which any current within the power of the instrument can be readily and instantaneously obtained, and as quickly reduced to a degree scarcely perceptible to the feeling, is, in my opinion, entirely new, and very perfect in its action on the human frame, as I have repeatedly experienced.

"Trusting the instrument will meet with that general use which I consider it entitled to,

"I am, My Dear Sir,

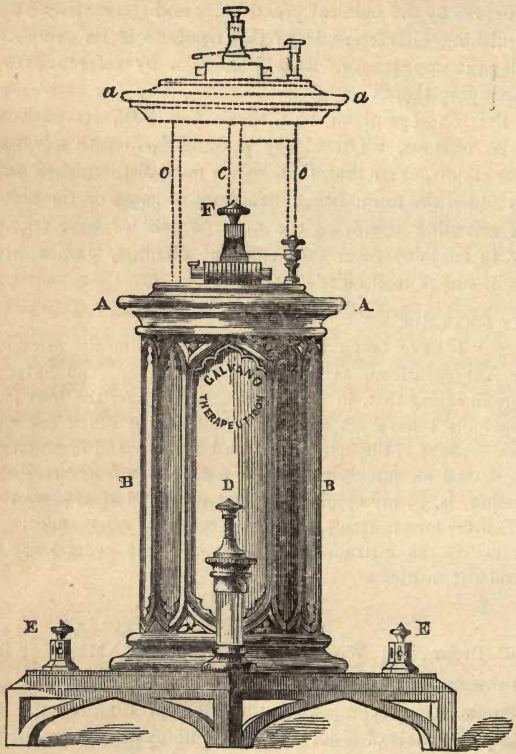
"Yours truly,

"To C. Brown, Esq. Woolwich." "JAMES MARSH."

To the experience of Mr. Marsh, might be added that of the numerous officers composing the Medical Staff of the Royal Military Hospitals of Woolwich, and of many private practitioners, to the successful employment of Galvanism therapeutically. In the practice of Mr. Brown are very many and highly interesting cases, a selection from which may on some future occasion be given.

The figure 15, together with the instructions for use, will convey a sufficiently correct idea of this beautiful and unique machine, and will prevent the necessity of giving a more lengthened description.

Fig. 15.



DIRECTIONS FOR USING THE GALVANO-THERAPEUTICON.

The top, A A, is to be drawn entirely out of the coil B B, in order to supply the glass jar within with the acid, to the height of the

red ring marked upon the glass.* The top AA is then to be replaced, care being taken that the guides, c c c, are *all external* to the glass; that is, the plates only are to be in the acid: the guides require a slight compression in thus returning them to their place. The screw D of the regulator is to be turned until the fine point within the glass tube is clear of the coloured water. The conducting wires. The conducting wires are now well secured, one in each binding screw E E: should the vibration under the screw P not be regular and rapid, the screw must be turned higher or lower as is necessary. The operator now taking hold of the handles, and the screw of the regulator D being slowly turned by the operator to meet the coloured water, the current will pass, the strength increasing as the point descends, *et vice versa.*

SUSPENDING OPERATIONS.—The top AA is to be steadily raised to the position shewn by the dotted lines *a a*, when the guides *c c c* will spring and suspend it until again required for use.

Considerable care being necessary in the construction of this machine, we would caution purchasers, in order to avoid disappointment, that in no case can a machine be warranted perfect, unless it has the name and address of the sole manufacturers by appointment, (Messrs. WILLATS, Cheapside, London), conspicuously placed upon it, and having the signature of the inventor upon the label.

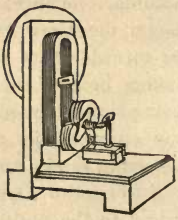
MAGNETO-ELECTRIC MACHINES.

As Electricity, under certain conditions, gives rise to magnetism, so magnetism, in its turn, can be made to evolve electricity. Our celebrated countryman, Faraday, was the first to discover that magnetism conjoined with motion may be made the source of electricity. It would be foreign to a work of this kind, and

* The acid employed is one part of sulphuric acid to eight parts of water. This being once supplied, will last for months, any little loss by evaporation being made up with water.

would carry us beyond our limits, were we to attempt to describe the beautiful experiments by which that philosopher was enabled to prove the fact; suffice it to say, that on this principle have been constructed machines, by which a current of electricity is set in motion without the aid of a battery. The general form of one of these instruments is seen in the accompanying figure. It consists of a horse-shoe magnet, which is fixed to a frame; opposite its poles is placed what is termed the armature, which can be rapidly revolved by means of a multiplying wheel. The armatures are nothing more than electro-magnets, such as we have already described; and by means of the wheel, each pole of the armature is brought in rapid succession opposite each pole of the magnet, and that as nearly as possible without touching; and a most brilliant succsesion of sparks, forming almost a continuous light, is produced. The shocks from these machines too, are very powerful; but as it is a matter of no inconsiderable difficulty to regulate them according to the necessity of the case, the use of the Magneto-Electric Machines in medicine is very limited.

Fig. 16.



Chapter VI.

ON THE DETECTION OF NEEDLES AND OTHER STEEL INSTRUMENTS IMPACTED IN THE BODY, BY ELECTRO-MAGNETS.

Before bringing this little work to a conclusion, it is deemed necessary to draw attention to a most valuable and important application of the principles of electro-magnetism, recently proposed by Mr. Alfred Smee. Every medical practitioner

must have had frequent opportunities of observing cases, in which portions of steel are introduced into the body, in the shape of needles, or as points of cutting instruments: frequently such foreign bodies remain unnoticed, and without producing any mischief for some lengthened time, and ultimately, perhaps, find their way to the surface; a small abscess is formed, and they are thus discharged. But although this is a frequent termination of such accidents, unfortunately it is not the only one; it occasionally happens that they become lodged in a joint; the affected part will swell, suppurate, and discharge; ulceration of the cartilages and osseous tissue supervenes; and the mischief is generally so great as to produce anchylosis. Such a case occurring to Mr. Smee, induced him to turn his attention to the subject. "Some time since," writes Mr. Smee,* "I had a case under my care, where a small portion of a needle was introduced into one of the joints of the finger, but of which no indication existed, beyond the effects which might have been expected from the presence of a foreign body. The exact spot of its insertion was unknown, and indeed, it was equally uncertain whether it was inserted or not. Subsequently, the joint swelled, suppurated, and discharged, and a small piece of needle was found firmly impacted in the bone. Now a very small piece of foreign matter is capable of producing such disastrous results, and on having weighed the piece discharged in this case, I found that it scarcely amounted to the seventh of a grain. Now it occurred to my mind that, had I known that the needle was actually present, and could have demonstrated the exact spot, I might have possibly averted the present inconvenience of a stiff joint to the unfortunate sufferer; and after having carefully considered the matter, a plan suggested itself to my mind for the detection of needles in future cases."

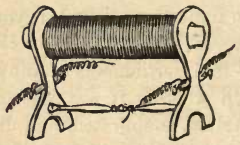
The plan by which Mr. Smee proposes to remedy such accidents, depends upon the well-known fact, that steel may, in many ways, be rendered magnetic;—thus, by the approximation of a powerful magnet, by the circulation of a current of electri-

* Reported in the Medical Times.

city around it or in its immediate vicinity, it evinces magnetic properties. Now one of the most important properties of a magnet is, it will be remembered, that its north pole will repel the north pole of another magnet brought near it, but attracts its south pole, the converse being the case with regard to the south pole.

These facts being known, the principle on which Mr. Smee acts is readily understood. The first point is to render the suspected piece of steel magnetic. The mode of effecting this may be best described in the words of Mr. Smee:—"When you suspect the presence of a piece of needle, or other steel instrument, you must subject the suspected part to a treatment calculated to render the needle magnetic; and this is best done by electro-magnetism. I have tried many forms of instruments, but should prefer that represented in the accompanying diagram, which is made of a simple bar of soft iron wound round with wire. The iron has a plate of brass, B, fixed in both ends to retain the wire (*w*) in situ; and the two ends of the wires are attached to binding screws (*s*).

Fig. 17.

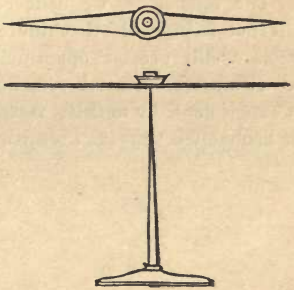


When this instrument is connected with the poles of a voltaic combination—(and for this purpose any battery possessing sufficient power may be employed, as, for example, a single cell of Grove's or Smee's already described)—it is to be kept in close approximation with the suspected part for some little time, and if there be a portion of steel conveyed therein, it will be endued with magnetic properties.

To test the existence of the magnet within the body is the next point necessary, for which purpose a common sewing needle previously rendered magnetic, and suspended by a portion of silkworm's silk, may be employed. But it will be found that the most convenient apparatus for the purpose is such as is represented in the diagram. (Fig. 17.) It consists of a delicate needle, about six inches long, centred upon a small agate cup

resting upon a steel point, so that the smallest possible amount of resistance is offered to its free play.

Fig. 18.



When a part containing magnetic steel is brought near the needle, it may be either attracted or repelled; it may move upwards or downwards; or it may exhibit disquietude according to the position in which the new magnet is held. We may detect the position of the foreign body, when it is of any size, by ascertaining where its north and south poles lie; and these are determined by their repelling and attracting the opposite poles of the magnetic needle. The disquietude, or motion upwards and downwards, merely indicate magnetism, but not the direction of the magnet. Mr. Smee has had more than one opportunity of proving the practicability and efficiency of the plan. In one instance, he succeeded in detecting a piece of needle impacted in the finger of a young woman, although, upon removal, it weighed but the seventh part of a grain. It gave such marked indications, that he was enabled to ascertain tolerably well the positions of its north and south poles, and consequently its exact situation.

In performing these experiments, it is necessary to be careful to continue the voltaic current in the same direction; for if it be reversed for one instant, it would tend to demagnetise the previously magnetised steel.

In bringing this little work to a conclusion, the author can only venture to express a hope that his efforts to draw attention to the advantage which, in many cases of disease, may be derived from Electricity in some of its modifications, have not been altogether fruitless. The science is, we believe, but now in its infancy, and it is not improbable that future discoveries may place in our hands a still greater opportunity of alleviating human suffering. It must be remembered, however, that it is only by constant experiment, by untiring research, that we are likely to be made acquainted with such results.

APPENDIX.

Since the foregoing pages were printed, our attention has been drawn to some further application of electricity, the results of which appear to us of much importance. Dr. Radford, of Manchester, was the first who suggested the application of Galvanism in *Uterine Inertia*, and the success which attended its use in his hands, has been amply confirmed by other practitioners. In the Lying-in Charity of Guy's Hospital it has been on many occasions had recourse to with the most marked advantage. A case of this nature was published some short time back; and as it tends to show when the application of galvanism is indicated, we subjoin it entire in the words of the author, Mr. F. W. Cleveland.

"I was requested to see Mary Cook, æt. 39, in her sixteenth confinement, on Friday morning, the sixth of June. On my arrival at the house, I learned that her previous labours had been tolerably good, with two or three exceptions, when they had been considerably protracted from want of pains. Her health has always been delicate, and for the last few weeks she has had a troublesome cough, attended with copious expectoration; emaciation and occasional night-sweats—symptoms which naturally led to the opinion that she was suffering from phthisis, although subsequently this diagnosis was not confirmed by a physical examination of the chest. On the Sunday evening prior to my visiting her, she was first attacked with premonitory symptoms of labour, soon succeeded by regular and frequent pains, which, on the following morning, abated, but never entirely left her till the Wednesday night, when the liquor amnii was discharged. At one A.M. on the Friday, the pains

returned with considerable vigour, but did not last above an hour, and at six were again renewed for a short time. It was about four hours after this period that I found Mr. T. with the patient, to whom he had given a dose of the tincture of ergot, and also some spirit and water; but these measures were followed by only a few slight and ineffectual pains.

"On making an examination, I found the vagina freely lubricated, the os uteri dilated, the head of the child small, presenting in the right oblique diameter, and in the pelvic cavity; in fact, there appeared no obstacle whatever to the completion of the case but uterine inertia, which I considered was owing to constitutional debility, arising chiefly from the state of the chest. She had now rather an anxious countenance, a small and frequent pulse; complained of great thirst and languor, and of having had no sleep for several nights.

"It was obvious that if uterine contraction could not be somehow induced, and it must be remembered that the ergot had been already tried, the alternative would eventually be instrumental delivery; and this, considering the weak state of the patient's health, and the not improbable and unpleasant result of hæmorrhage from atony of the womb, was not desirable. At the suggestion of Dr. Lever, who kindly lent me his electro-galvanic apparatus, I resolved on a fair trial of galvanism, and accordingly, with my friend Mr. Richardson, proceeded to its application externally and obliquely across the anterior surface of the uterus. In a few minutes the effect was very apparent; regular, strong, and frequent pains came on, and in a quarter of an hour from the first application of the remedy, a living male child and placenta were expelled, attended with the least degree of hæmorrhage I ever witnessed. The uterus was immediately firmly and permanently contracted, and, with the exception of slight soreness of the abdomen, the patient expresses herself as quite comfortable, and since that time, setting aside debility, she has progressed favourably."

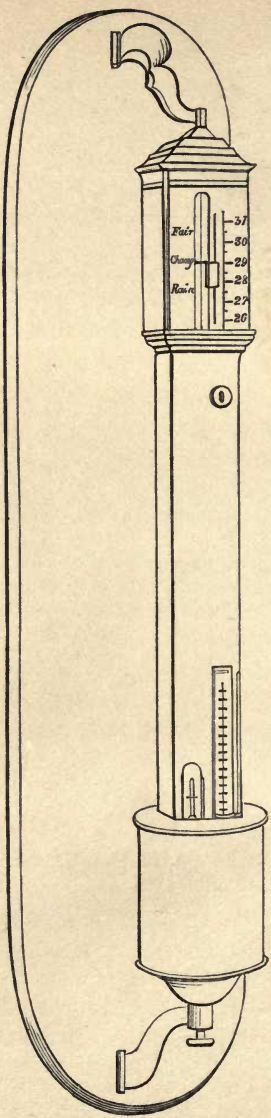
In Guy's Hospital, galvanism has been recently applied in a case of *Irritable Stump* after amputation of the thigh. Five or six applications, each lasting about twenty minutes, gave great

relief, and ultimately, from its continued use, perfect ease was obtained by electricity when other means are without effect.

There is one other class of disorders in which electricity seems to be very valuable, and particularly so, as they often resist all other means of cure; viz. those which depend upon *Spinal Weakness*, as shown by loss of power, sometimes and most frequently only in the lower extremities, at others extending to all the muscles of the body. In Guy's Hospital, during the last two years, there have been many cases of this kind. The following is the outline of one:—A male patient, aged forty years, had lost power in the lower extremities, probably from working in a damp situation; he was too weak to walk without being supported on either side, and then his gait was very awkward, as he was unable to direct the muscular movements. He had been under the ordinary treatment of tonics, &c. for a long time, without any benefit; as a last resource, sparks were ordered to be drawn from the region of the spine. At the end of two months he was well, and has continued so up to this time. Many similar cases might be cited were it necessary.

As it is the sole object of the author to make this work a record of the progress of Electricity as applied to Medicine, he takes the liberty of soliciting from any practitioners, who may have derived advantage in its application, particulars of the cases in which it has proved efficacious; addressed to the care of the publishers, Messrs. T. and R. Willats, 98, Cheapside.

THE END.


Fair
Change
Rain
31
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26

A MANUAL

OF

THE BAROMETER;

CONTAINING AN EXPLANATION OF THE

CONSTRUCTION AND METHOD OF USING THE MERCURIAL BAROMETER, WITH APPROPRIATE TABLES FOR CORRECTIONS FOR TEMPERATURE, AND RULES FOR OBTAINING THE DEW-POINT AND THE HEIGHTS OF MOUNTAINS:

TO WHICH ARE ADDED,

AN ORIGINAL TABLE OF THE MEAN HEIGHT OF THE BAROMETER FOR EVERY DAY OF THE YEAR, AND PHÆNOMENA OF THE WINDS AND CLOUDS IN THEIR CONNEXION WITH THE CHANGES OF THE WEATHER:

ALSO,

A DESCRIPTION OF THE ANEROID BAROMETER.

BY JOHN HENRY BELVILLE,
OF THE ROYAL OBSERVATORY, GREENWICH.

LONDON:
RICHARD AND JOHN EDWARD TAYLOR,
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1849.

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PREFACE.

In the preliminary Chapter on the Atmosphere I have referred to De Luc's 'Recherches sur l'Atmosphère,' Robertson on the Atmosphere, and Dalton's Essays. The barometric table of the mean height of the mercurial column for every day in the year is, I believe, the first of the kind that has been deduced; it is the result of thirty years' observations, made by myself in one locality. In the name of "Henry" my table of daily mean temperatures was used for two or three years, at the Royal Observatory, as a standard of comparison for the temperatures in the weekly report of the Registrar-General, and it was only discontinued when the establishment had accumulated sufficient data from which to deduce a standard of their own: that

public acknowledgement of confidence in the accuracy of those results, together with my professional character as an observer, will give the value of authenticity to the Table now published. The phænomena of the winds and clouds, in their connexion with the movements of the barometer, though deduced from observation and experience, are not set forth as dogmas, but as helps, for the interpretation of the meteorological appearances of our very irregular and unsettled climate. The nomenclature of the clouds is Luke Howard's, by whom, when a young observer, I was favoured with a presentation copy of his valuable work on the *Climate of London*.

J. H. B.

Greenwich, April 1849.

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ON

THE ATMOSPHERE.

THE Barometer is an instrument for measuring the weight of the atmosphere; it was invented in 1643 by Torricelli, who in investigating the cause of water ascending in pumps to the height of 32 feet, and no higher, made the following experiment. He took a glass tube about four feet long, sealed at one end and open at the other, and having filled it with mercury closed the open end with his finger; he then inverted the tube, and placed the open end under the surface of a small quantity of mercury in a bason, and raising the tube perpendicular withdrew his finger; he observed the mercury in the tube suspended to the height of $27\frac{1}{2}$ inches, above the surface of that in the bason: he compared the height of the column of mercury with the height of the column of water raised by the pump, and perceiving those heights to be in an inverse ratio of the specific gravities of the water and mercury, he concluded they were kept in suspension by a common cause; a further consideration of the experiment led him to remark that

the upper extremities of the columns of water and mercury had no communication with the atmosphere, but that the lower extremities had a communication, and he attributed the elevation of the columns in the tubes to the weight of the atmosphere.

The curious may amuse themselves with the action of the weight of the atmosphere in the following manner:— Take a glass tube of uniform bore, open at both ends; fit a cork to it, and cement a wire into the cork, which will form a piston to the tube; place the piston even with the lower end of the tube; and in that situation place the same end of the tube in mercury; hold the tube steadily and pull up the piston; the mercury will follow the piston, and will fill that part of the tube which is below the piston. By this means the weight of the atmosphere is removed from off the mercury, which is forced into the tube as far as the piston, by the weight of the atmosphere on the rest of the surface of the mercury in the bason; when the mercury in the tube balances the weight of the atmosphere, it remains stationary; and on pulling the piston higher, the space between it and the mercury is called a vacuum, or space void of air.

In 1646 Pascal at Rouen repeated Torricelli's experiments with similar results. He also varied them by employing liquids of different specific gravities, and he perceived that the lighter the liquid the higher it ascended in the tube; but the agency of an invisible fluid was still doubted, and he therefore determined to make an experiment on the top of the mountain Puy de Dome,

near Clermont in Auvergne, which should silence controversy. Two tubes filled with mercury, the columns of equal heights, were carried to the foot of the mountain, one of which was left there standing at 28 inches, and the other taken to the summit; as they ascended, the mercury in the tube gradually sunk until it stood at 24·7 inches; as they descended, the mercury as gradually rose again; and when placed by the side of the tube left below, their elevations coincided. As Pascal had anticipated, in ascending the mountain the weight of a portion of the column of the atmosphere equal to the height of the mountain being removed from the surface of the mercury in the bason, that which was in the tube fell, until its weight was again counterpoised by the atmosphere; and conversely in descending, the weight of the column of the atmosphere being increased by the weight of the portion equal to the height of the mountain, pressed upon the mercury in the bason, and forced it to ascend in the tube until both weights balanced each other.

Pascal originated the idea of measuring elevations by the variations of the barometer, but he foresaw a difficulty. He compared the atmosphere to a mass of wool, the lowest parts of which were more pressed than those above; and his sagacity led him to the fact, that from the dilatation of the atmosphere the rise and fall of the mercurial column would not be equal through equal spaces. This concluded his philosophical inquiries; he afterwards turned his attention to theology.

In 1666 Boyle discovered that the atmosphere was

elastic and compressible; and about the same period Mariotte proved its density was in proportion to the weight with which it was compressed. The stratum of the atmosphere nearest the surface of the earth supports the weight of all above it, and is the densest; each stratum as we ascend becomes lighter or more rare, because its elasticity is less checked by having a less weight pressing from above. Père Cotte deduced, that the ratio of the decrease of its density was in geometrical progression, if we take the heights in arithmetical progression. Thus, if the density at 1 mile high was 1, and that at four miles high $\frac{1}{2}$, then that at 7 miles high would be $\frac{1}{4}$, at 10 miles high $\frac{1}{8}$, at 13 miles high $\frac{1}{16}$, &c.; but this ratio is much disturbed by changes in the temperature of the strata of the atmosphere at different elevations. Heat expands the bulk of air, and forces it to occupy a larger space; 1000 volumes of air at 32° of Fahrenheit become expanded into 1057·34 volumes at 60°; thus heat is a cause of the unequal rise and fall of the barometer through equal spaces. Sir George Shuckburgh made numerous experiments upon the effects of temperature on the atmosphere; and from his labours we have a table, which shows in feet how much the spaces passed through may vary from temperature in a fall of $\frac{1}{10}$ of an inch of mercury, the barometer standing at 30 inches; and by means of his theorem for its application, we are now enabled to ascertain the heights of mountains by the barometer as correctly as by geometrical measurement.

There exists at all times in the atmosphere a certain

portion of vapour, which exerts an influence, varying according to circumstances, upon the mercurial column; it is derived from the spontaneous evaporation of water from the surface of the earth, and is called *aqueous vapour*. Evaporation is promoted by dry air, by wind, by a diminished pressure, and by heat; the *quantity* evaporated is dependent upon temperature; for heat expanding the gaseous portion of the atmosphere, the spaces between its particles are enlarged and their capacities for containing moisture augmented. Aqueous vapour is highly elastic; its elasticity, which increases with an increase of temperature, has been determined by Dalton, and its force measured by the height of the mercurial column it is capable of supporting. Aqueous vapour, raised at 32° of Fahrenheit, exerts a pressure on the mercury equal to 0·2 of an inch, at 80° to 1·03 inch, at 180° to 15·0 inches, and at 212° to 30·0 inches, —a pressure equal to the pressure of the whole atmosphere at the level of the sea. The quantity of vapour existing in the atmosphere is measured by an Hygrometer. The one now in general use consists of two thermometers, one bulb of which being covered with muslin and kept constantly moist, will, according to the quantity of evaporation at the time of observation, stand lower than the other bulb, which being left free gives the temperature of the air: from the difference of the readings of the two thermometers, we are able by a very simple rule to obtain the *dew-point*, or that degree of the thermometer to which the temperature of the air must fall for the atmosphere to become saturated with

the quantity of vapour then actually existing in it, as will be shown by the following example:—

Let free thermometer ...	$=63^{\circ}$	63° = temp. by free ther.
Wet thermometer	$=54$	$16{\cdot}2$
Difference.....	$= 9$	$46{\cdot}8$ = dew-point :
Factor to multiply difference	$= 1{\cdot}8$	By table 0·337 of an inch = elasticity of vapour in atmosphere.

$16{\cdot}2$ = number of degrees to be subtracted from free therm.

If the readings of the two thermometers be alike, the temperature of the *dew-point* will be the same as the temperature of the air; and the air will then be saturated with moisture.

It is chiefly in the nights, and early in the mornings of the winter months, that the atmosphere is saturated with vapour, or that vapour is at its *maximum* of elasticity for the temperature. In our climate, vapour never attains its greatest elasticity at a high temperature; for if in the summer months the atmosphere becomes saturated, it is caused by a declension of the heat, which, contracting the spaces between the particles of the air, squeezes the vapour contained in them closer, and thus brings its elasticity to a maximum for the temperature to which the air has fallen. It was upon the changes of temperature in the atmosphere that Dr. James Hutton founded his theory of rain. He considered rain to be formed by the mixture of two strata of the atmosphere of different temperatures, and each saturated with moisture. The mean quantity of the vapour contained by the two strata before the mixture being more than

the mean heat of the two (after the combination) can contain, the excess is precipitated :—

Let temp. of one stratum	$=65^{\circ}$	its tension or elasticity	$=0{\cdot}61$ in. by table.
Let temp. of the other...	$=41$	... ...	$0{\cdot}27$
	$2\|106$		$0{\cdot}88$
Mean temperature after combination	53	Mean tension after combination.....	$0{\cdot}44$

By table, the tension of vapour at 53° is 0·40 inch.

Therefore vapour of the tension of 0·04 inch of the mercurial column is precipitated in cloud, fog or rain.

Heat and moisture are the principal causes of the variations in the weight of the atmosphere, and necessarily of the variations in the barometer; the moon is considered to have some influence; but if she exert any power in causing accumulations or tides in the atmosphere, her action on the barometer, computed to be about $\frac{1}{100}$ of an inch, is so small, that even with the most delicate instruments and the most accurate observers we can scarcely hope to demonstrate it satisfactorily.

The variations of the barometer are less within the tropics than in the temperate and polar regions; they vary in different countries in the same latitude, and they are great in mountainous countries and islands; in Peru the range of the mercury is about $\frac{1}{3}$ of an inch, in London $2\frac{1}{2}$ inches, and in St. Petersburg it exceeds 3 inches.

The pressure of the atmosphere at the level of the sea, the barometer at 30 inches, is 15 lbs. on the square

inch, which amounts to 2160 lbs., or nearly a ton, upon every square foot. We cannot therefore be surprised at the effects of so elastic and compressible a body as air, when it is set in motion; the soft breeze of summer and the furious hurricane of winter are instances of the effects of its different velocities.

On the Construction and Method of Using the Mercurial Barometer.

There are various forms of the Barometer, but the one best suited for meteorological observations consists of a tube about 33 inches in length, the extremity of which is inserted into a small reservoir or cistern; and in order to maintain the mercury in the cistern always at the same level, the cistern is constructed partly of leather; that by means of a screw at the bottom, the surface of the mercury in it may be so adjusted, as to have it always at the place from which the scale commences. Some barometers are furnished with a gauge or float, that in great elevations and depressions the observer may perceive when the mercury in the cistern sinks too low or rises too high.

Let *a b*, fig. 1, be the glass tube plunged into the mercury in the cistern C, and D the surface-line of the fluid in the cistern level with the commencement of the scale, and adjusted to the particular height of the mercury in the tube, which has been actually measured from the surface of the cistern, in the construction of

the instrument (which height is called its neutral point): when the mercury rises in the tube, a portion equal to that rise leaves the cistern, and the surface-line falls towards the dotted line *e*; and being lower than the surface from which its neutral point was measured, the actual variation in the atmosphere is indicated too little: turn the screw *f* until the lines on the float *h* coincide, and the mercury then records the exact change: when depressions occur, the mercury sinking from the tube into the cistern raises the surface-line towards *g*; in this case the screw *f* must be unscrewed until the leather at the bottom of the cistern be sufficiently loosened to allow the mercury to assume its proper level at the surface D.

Fig. 1.

When there is not a gauge to the barometer, the relative capacities of the cistern and tube are ascertained by experiment, in the construction of the instrument, and marked thereon; as is also its neutral point. In this case, when the mercury in the tube is above the neutral point, the difference between it and the neutral point is to be divided by the *capacity*, and the quotient *added* to the observed height will give the correct height; if the mercury be below the neutral point, the difference is to be *divided* as before, and the quotient *subtracted* from the observed height will give the correct height.

Let capacity for every inch of elevation of the mer-

cury in the tube be equal to $\frac{1}{40}$, which, reduced to a decimal, will be

in. in. in.
=0·025 for one inch., 0·013 for $\frac{1}{2}$ inch, 0·007 for $\frac{1}{4}$ in.

	in.		in.
Observed height...	=30·400	Observed height.....	29·500
Neutral point.....	=30·000	Neutral point.....	30·000
Difference above neutral point	·400	Difference below neutral point.....	·500
Add for capacity	+ ·010	Subtract for capacity	− ·013
Correct height ...	30·410	Correct height	29·487

The scale of the standard barometer used in fixed observatories is made moveable, and terminates in an ivory point, which is brought down to the surface of the mercury: when this point and its reflection appear to touch one another, the height indicated is correct. This kind of barometer requires no adjustment or correction for the cistern.

The tubes of barometers vary in size: those of a large diameter are preferable, as the motion of the fluid is freer, and its friction against the sides of the tube is nearly inappreciable; tubes of small diameters require correction for capillarity, or the depression of the mercury caused by its adhesion to the sides of the tube.

The range of the barometer, or the spaces passed through by the mercury in its extreme depressions and elevations, being limited to $3\frac{1}{2}$ inches, it is not usual to graduate the scale from the lower end of the tube: the divisions commence at 27 inches, and are continued to 31 inches. The graduations on Troughton's mountain

barometers for measuring great elevations, commence at 15 inches and are carried on to 33 inches. Each inch is divided into ten equal parts, and these parts are subdivided into hundredths by means of a Vernier (so named from Peter Vernier, its inventor). The Vernier (A, fig. 2 & 3) is a moveable plate, one inch and one-tenth of an inch (together equal to $\frac{1}{10}$) in length; these eleven-tenths are divided into ten equal parts, each part being equal to one-tenth of an inch and one-tenth of a tenth, together equal to eleven hundredths. When the pointer of the Vernier coincides with a division of the barometer scale, as in fig. 2, each division of the Vernier will exceed each division of the scale respectively by 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 parts, whose denominators are the number of parts between *a*, *b*; the excess of each division being $\frac{1}{10}$ of a tenth or $\frac{1}{100}$, $\frac{2}{10}$ of a tenth or $\frac{2}{100}$, $\frac{3}{10}$ of a tenth or $\frac{3}{100}$, $\frac{4}{10}$ of a tenth or $\frac{4}{100}$, &c. The pointer in this position reads off to inches and tenths, viz. thirty inches and one tenth, expressed in figures 30·10 inches.

When the *pointer* does *not* coincide with a division of the scale as in fig. 3, observe which division of the Vernier does coincide; and the number placed against that division of the Vernier will be the number of hundredths to be added to the inches and tenths. In fig. 3, 7 coincides with a division of the barometer scale, and therefore 7 hundredths are to be added to the inches and tenths, and the reading is thirty inches, one tenth and seven hundredths, expressed in figures 30·17 inches. By an alteration in the divisions of the Vernier, the mountain and standard barometer are read off to $\frac{5}{100}$ of an inch.

A thermometer is attached to the barometer to indi-

Fig. 2.

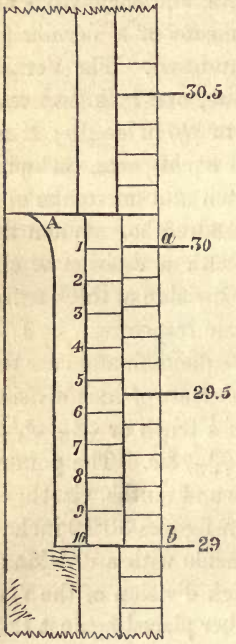
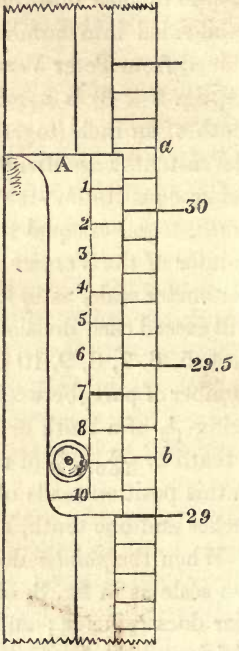


Fig. 3



cate the temperature of the mercury in the cistern; all bodies expand by heat and contract with cold; the expansion of mercury is easily tested by exposing a mercurial thermometer to the heat of a fire, or by placing it in hot water: as the warmth increases, the mercury will expand and ascend into the tube; as it diminishes, it will contract and fall towards the bulb: if the ther-

mometer be plunged into a mixture of pounded ice and common salt, from the intense cold produced by the conversion of the ice into water, the mercury will sink to zero, or 32° below the freezing-point of Fahrenheit; if the tube of the thermometer should not be long enough to admit of so low a graduation, the mercury will shrink into the bulb. The expansion of mercury is $\frac{1}{9000}$ of its bulk for each degree of Fahrenheit between 32° and 212°. For convenience tables have been computed, from which may be taken out, at sight, the amount to be subtracted from the height of the mercurial column, on account of the expansion of the mercury from temperature.

The words Change, Fair, and Rain, engraved on the plate of the barometer, were placed there by the first observers of its variations: no great importance should be attached to them; for from the observations of two centuries we find, that heavy rains, and of long continuance, take place with the mercury at 29·5 inches or Change; that rain frequently falls when it stands as high as 30·00 inches, or Fair; and, more particularly in winter, a fine bright day will succeed a stormy night, the mercury ranging as low as 29·00 inches, or opposite to Rain. It is not so much the *absolute* height as the actual rising and falling of the mercury which determines the kind of weather likely to follow. The late great elevation of 30·90 inches in February of the present year 1849, was succeeded by a minimum of 29·25 inches, which produced a storm of wind so violent that the horizontal pressure of many of the gusts amounted to 20lbs. upon the square foot; a pressure which is rarely exceeded, even when

the barometer falls as low as 28·25 inches. This may appear extraordinary if we merely take into consideration the actual height of the column, and neglect the *quantity* of the fall which amounted to 1·65 inch. The mean height of the greatest observed elevations for the last thirty-eight years is 30·61 inches, and the mean height of the observed depressions for the same period is 28·69 inches; therefore a fall in the mercury of 1·65 inch from the mean of the elevations would give a *minimum* of 28·96 inches; a depression which is contemporary with violent storms, as it is within three-tenths of the mean of the lowest depressions of the barometer.

In fixing the barometer great care must be taken to fix it perpendicular: a situation should be selected subject to the least change of temperature, for which reason a northern aspect is preferable to a southern; the height of the cistern of the barometer above the level of the sea, and, if possible, the difference of the height of the mercury with some standard, should be ascertained, in order that the observations made with it should be comparative with others made in different parts of the country. Before taking an observation, the instrument should be gently tapped to prevent any adhesion of the mercury to the tube, the gauge should be adjusted to the surface-line of the cistern, and the index of the Vernier brought level with the top of the mercury. If the barometer have a Vernier which admits the light from behind, the lower part of the pointer must make a tangent with the convex part of the mercury in the tube. In reading off the observation the eye should be on a line with the mercury; as by placing it above, the reading would be

too low, and by placing it below, it would be too high. This difference in the manner of reading off is called error from parallax. It is indispensable that a reading of the attached thermometer be made simultaneously with the observation of the height of the mercury. Accuracy is the spirit of observation. A careful reading of inches, tenths and hundredths produces excellent results: the $\frac{1}{1000}$ place is better left to the skill of the old observer who is usually obliged to estimate it, scarcely any barometer being graduated with sufficient precision to trust to the divisions for so small a quantity.

The barometer is slightly affected periodically during the twenty-four hours: at 9 A.M. and 9 P.M. it stands higher, and at 3 A.M. and 3 P.M. it stands lower; the mean annual difference amounts nearly to ·03 of an inch. These four periods of the day have been recommended for observation by the Committee of Physics of the Royal Society. It is usual, for the sake of comparison, to reduce the observations to 32° of Fahrenheit.

		in.
Ex.	If barom. stood at	29·900 therm. attached 54°,
	Correct for temp.	−·057 (by table),
	Height of barom. at temp. of 32°	29·843

The wheel-barometer, from its construction, cannot be trusted to for correct heights; it merely shows if the mercury be in a rising or falling state: it may rather be considered as an ornamental piece of furniture than as having the slightest pretensions to a scientific instrument.

Mean height of the Barometer at noon for Greenwich, secutive years' observations, viz. from 1815 *to* 1844, 60 *feet above the level of the Sea.*

Day of the month.	January.	February.	March.	April.	May.	June.
1.	29·987	29·831	29·763	29·909	29·881	29·941
2.	·997	·748	·791	·843	·876	·904
3.	·971	·851	·774	·915	·834	·879
4.	·892	·807	·766	·944	·815	·855
5.	·964	·886	·828	·959	·819	·860
6.	·977	·919	·796	·873	·822	·912
7.	·981	·851	·739	·835	·859	·939
8.	30·020	·911	·777	·852	·861	·911
9.	30·014	·924	·821	·847	·864	·914
10.	29·876	·954	·866	·882	·889	·917
11.	·807	·964	·869	·848	·908	·935
12.	·885	·937	·903	·774	·878	·964
13.	·806	·963	·901	·851	·838	·934
14.	·819	·904	·924	·878	·862	·895
15.	·863	·926	·893	·884	·857	·887
16.	·897	·897	·931	·817	·856	·934
17.	·920	·864	·944	·851	·888	·930
18.	·956	·887	·996	·872	·867	·893
19.	·889	·846	·938	·925	·898	·901
20.	·885	·811	·877	·911	·882	·885
21.	·890	·811	·879	·861	·917	·895
22.	·865	·865	·831	·800	·939	·884
23.	·889	·841	·804	·745	·944	·900
24.	·903	·789	·807	·797	·895	·893
25.	·922	·789	·814	·888	·877	·905
26.	·876	·761	·867	·902	·848	·904
27.	·899	·702	·914	·879	·921	·920
28.	·869	29·802	·846	·889	·936	·911
29.	·898	.....	·880	·838	·947	·956
30.	·866	.....	·902	29·832	·964	29·955
31.	29·881	.....	29·925	.....	29·957	.....
Means.	29·909	29·859	29·857	29·865	29·884	29 910

Kent, for every day of the year, deduced from thirty con-
and reduced to 32° Fahrenheit. Assumed elevation

July.	August.	September.	October.	November.	December.	Day of the month.
29·921	29·945	29·881	29·747	29·814	29·778	1.
·918	·928	·919	·834	·816	·789	2.
·915	·869	·928	·902	·789	·839	3.
·925	·826	·913	·896	·793	·846	4.
·902	·862	·904	·907	·785	·909	5.
·903	·868	·860	·897	·782	·868	6.
·899	·904	·852	·863	·782	·839	7.
·878	·902	·805	·875	·794	·809	8.
·912	·886	·843	·883	·853	·869	9.
·926	·869	·844	·875	·764	·927	10.
·865	·884	·896	·836	·802	·950	11.
·849	·925	·896	·851	·846	·928	12.
·871	·888	·922	·917	·801	·919	13.
·887	·809	·893	·925	·744	·962	14.
·874	·822	·881	·924	·756	·943	15.
·937	·884	·887	·868	·739	·885	16.
·939	·927	·917	·842	·879	·825	17.
·827	·919	·889	·893	·917	·745	18.
·821	·921	·929	·862	·944	·851	19.
·804	·893	·912	·822	·906	·815	20.
·846	·892	·840	·874	·783	·874	21.
·899	·884	·840	·838	·746	·891	22.
·899	·889	·839	·764	·761	·851	23.
·896	·904	·809	·734	·797	·815	24.
·922	·908	·858	·774	·839	·868	25.
·955	·914	·875	·813	·829	·907	26.
·957	·925	·839	·814	·858	·890	27.
·984	·894	·848	·844	·737	·934	28.
·912	·892	·789	·863	·655	·992	29.
·861	·894	29·821	·838	29·745	·997	30.
29·889	29·865	.....	29·808	.....	·979	31.
29·894	29·890	29·872	29·851	29·801	29·884	Means.

The foregoing table of the daily mean heights of the barometer for Greenwich for every day of the year is the result of thirty years' observations made in one locality, and, with few exceptions for so long a period, by one person. The instrument by which the greater number were registered is by Watkins and Hill, the tube of which has a bore $\frac{6}{10}$ths of an inch in diameter. The table is original, and it may assist in confirming that, at certain seasons of the year, great periodic atmospheric *maxima* and *minima* take place. The greatest daily mean pressure for the year, which a consecutive five years' observations will not only verify but increase, occurs about the 9th of January, and the minimum daily mean depression towards the end of November. It is a remarkable coincidence, that the lowest daily mean temperature for thirty years occurs on the 8th and 9th of January, and the daily mean temperature for November rises suddenly four degrees in the last few days in November.

The greatest monthly mean pressure occurs in June, and the lowest in November.

From June the monthly mean pressure declines till November, when it again rises and attains a second maximum in January; and again falling, comes to its second minimum in March.

The mean annual pressure for noon at Greenwich is 29·872 inches.

A Table of the greatest and least observed heights of the Barometer for the last thirty-eight years, taken at Greenwich, and reduced to 32° of Fahrenheit.

Date of the year.	Greatest observed height of barometer.	Least observed height of barometer.	Greatest annual range.	Date of the year.	Greatest observed height of barometer.	Least observed height of barometer.	Greatest annual range.
1811	30·46	28·68	1·78	1830	30·63	28·61	2·02
1812	30·55	28·50	2·05	1831	30·58	28·93	1·65
1813	30·47	28·65	1·82	1832	30·64	29·12	1·52
1814	30·40	28·21	2·19	1833	30·71	28·77	1·94
1815	30·63	28·86	1·77	1834	30·66	29·13	1·53
1816	30·67	28·72	1·95	1835	30·84	28·74	2·10
1817	30·63	28·51	2·12	1836	30·69	28·62	2·07
1818	30·62	28·54	2·08	1837	30·68	28·77	1·91
1819	30·52	29·11	1·41	1838	30·58	28·61	1·97
1820	30·75	28·67	2·08	1839	30·57	28·97	1·60
1821	30·82	27·99	2·83	1840	30·68	28·59	2·09
1822	30·70	29·11	1·59	1841	30·49	28·82	1·67
1823	30·62	28·60	2·02	1842	30·58	28·69	1·89
1824	30·57	28·46	2·11	1843	30·54	28·20	2·34
1825	30·89	28·74	2·15	1844	30·53	28·63	1·90
1826	30·57	28·80	1·77	1845	30·57	28·77	1 80
1827	30·70	28·77	1·93	1846	30·66	28·66	2·00
1828	30·55	28·92	1·63	1847	30·53	28·48	2·05
1829	30·59	28·92	1·67	1848	30·48	28·40	2·08

In the preceding table the *maximum* elevation for the period of thirty-eight years occurred in 1825, when the mercury stood at 30·89 inches; in 1821 it however reached 30·82 inches; in 1835, 30·84 inches; and in February 1849, 30·86 inches. It is recorded that Sir George Shuckburgh, in 1778 in London, observed the barometer at 30·935 inches, which he believed to be the greatest elevation ever seen.

In the extreme depressions, those of 1821 and 1843

differ only by 21 hundredths: the first occurred on the 25th of December, when a Troughton's mountain-barometer at the Royal Observatory sunk as low as 27·89 inches. (See Pond's 'Greenwich Astronomical Observations, 1821.') A heavy rain of some hours' duration, with the wind at south-east, had preceded the minimum pressure; a gale from the north-west followed, in which the mercury rose a few tenths.

The depression of 1814, 28·21 inches, happened at the close of the great frost, and was likewise preceded by a stormy wind from south-south-east and much rain.

The difference of the extremes of the elevations is 0·49 inch.

The difference of the extremes of the depressions is 1·14 inch.

The following is the progress of the great depression of January 13, 1843.

Hour of the day.	Height of the barom.	State of the weather.
2 A.M.	29·02	Sky overcast with cirro-stratus: ground covered with snow: temperature 30°.
5.	28·72	Rain and Wind. Direction S.
7.	28·54	Wind unusually violent.
8.	28·48	
8·45.	28·41	Dense nimbi. Thunder and lightning. } Wind S.S.W.
9·15.	28·40	Dense nimbi. Rain and wind. }
10.	28·37	Tremendous squalls.
11.	28·34	Showers of rain discharged horizontally from nimbi.
Noon.	28·30	
1 P.M.	28·23	Wind blowing a hurricane from S.W.
2.	28·29	More moderate.
3.	28·34	
4·30.	28·37	Wind as violent as before, blowing down trees.
6.	28·48	Direction of wind W.
10.	28·68	Steady heavy gale from W. with scud. Temp. 38°·5.

It may be proper to observe, that neither *extreme* elevations nor *extreme* depressions occur suddenly, the mercury being usually for some few days preceding them in a gradually rising or falling state.

The horizontal pressure of the most violent gusts was 20 and 25 lbs. on the square foot, the wind having a velocity of 60 and 80 miles an hour.

A Table showing the age, declination, and position of the Moon in her orbit, in some of the most remarkable elevations of the Barometer.

Date of the year.	Day of the month.	Height of the barometer.	Moon's age.	Moon's declination.	Position of the Moon in her orbit.
1816.	Dec. 1	30·67	14	11° N.	Apogee.
1820.	Jan. 9	30·75	25	15 S.	Mean.
1821.	Feb. 6	30·82	5	10 N.	Perigee.
1822.	Feb. 28	30·70	8	27 N.	Perigee.
1825.	Jan. 9	30·89	22	Equator.	Perigee.
1827.	Dec. 28	30·70	10	20 N.	Apogee.
1833.	Jan. 8	30·71	18	15 N.	Perigee.
1835.	Jan. 2	30·84	3	18 S.	Mean.
1836.	Jan. 2	30·69	14	26 N.	Apogee.
1837.	Oct. 14	30·68	15	14 N.	Past perigee.
1840.	Mar. 8	30·68	4	22 N.	Perigee.
1849.	Feb. 11	30·86	18	Equator.	Mean.

A Table showing the age, declination, and position of the Moon in her orbit, in some of the most remarkable depressions of the Barometer.

Date of the year.	Day of the month.	Height of the barometer.	Moon's age.	Moon's declination.	Position of the Moon in her orbit.
1814.	Jan. 29	28·21	8	15° N.	Near perigee.
1817.	Dec. 8	28·51	New.	26 N.	Perigee.
1818.	Mar. 4	28·54	29	26 S.	Mean.
1821.	Dec. 25	27·99	3	25 S.	Perigee.
1824.	Nov. 23	28·46	4	20 S.	Apogee.
1830.	Jan. 20	28·61	27	17 S.	Past apogee.
1836.	Feb. 2	28·62	Full.	16 N.	Perigee.
1838.	Nov. 28	28·61	12	16 N.	Perigee.
1840.	Nov. 13	28·59	19	24 N.	Past perigee.
1843.	Jan. 13	28·20	13	24 N.	Mean.
1847.	Dec. 6	28·48	28	17 S.	Apogee.
1848.	Feb. 26	28·40	21	16 S.	Apogee.

Phænomena of the Barometer.

Strong winds in the winter from the west with a steady high pressure, invariably bring a high temperature and very little rain; with winds from the east, a low temperature and sharp frosts.

If the mercury fall during a high wind from the south-west, south-south-west, or west-south-west, an increasing storm is probable; if the fall be rapid, the wind will be violent, but of short duration; if the fall be slow, the wind will be less violent, but of longer continuance; the disturbing cause is probably the same in each case, but its intensity unequal: nearly all our

high winds from the south-west come with a falling barometer.

If the depression of the mercury be sudden and considerable with the wind due west, a violent storm may be expected from the north-west or north, during which the mercury will rise to its former height.

If the mercury fall with the wind at west, north-west, or north, a great reduction of temperature will follow; in the winter severe frosts, in the summer cold rains.

A steady and considerable fall of the mercury during an east wind denotes that the wind will soon go round to the south, unless a heavy fall of snow or rain immediately follow; in this case the *upper* clouds usually come up from the south. The deep snow of the severe winter of 1814 was a notable instance.

The lowest depressions occur with the wind at south and south-east, when much rain falls, and frequently short and severe gales blow from these points. In the winter months, sudden depressions of the mercury with the wind in these quarters are attended with electrical phænomena.

A fall of the mercury with a south wind is invariably followed by rain in greater or less quantities.

A falling barometer with the wind at north brings the worst weather: in the summer, rain and storm follow; in the winter and spring, deep snows and severe frosts. This case is of rare occurrence.

A great depression of the mercury during a frosty period brings on a thaw: if the wind be south or south-

east, the thaw will continue; if the wind be south-west, the frost will be likely to return with a rising barometer and northerly wind.

Great depressions in the summer months are attended with storms of wind and rain with thunder and hail: cold unseasonable weather generally succeeds these depressions.

Great depressions at all seasons are followed by change of wind, and afterwards by much rain.

During a period of broken cold weather in the winter months, with the wind at north or north-north-west, a sudden rise of the mercury denotes the approach of rain and a southerly wind.

During a steady frost with the wind at north, north-east, or east, a continued slow rising of the mercury indicates snow and cloudy weather.

If the mercury rise with the wind at south-west, south, or even south-east, the temperature is generally high.

Great elevations in the summer are attended with dry, warm weather.

A rising barometer with a southerly wind is usually followed by fine weather. In the summer it is dry and warm; in the winter dry with moderate frosts. This is of rare occurrence.

When the mercury is very unsteady during calm rainy weather, it denotes that the air is in an electrical state, and that thunder will follow.

In the summer months, if a depression of two or three

tenths of the mercury occur in a hot period, it is attended with rain and thunder, and succeeded by a cool atmosphere. Sometimes heavy thunder-storms take place overhead without any fall of the mercury; in this case a reduction of temperature does not usually follow.

If after a storm of wind and rain, the mercury remain steady at the point to which it had fallen, serene weather may follow without a change of wind; but on the rising of the mercury, rain and a change of wind may be expected.

During a series of stormy weather the mercury is in constant agitation, falling and rising twice or thrice in the space of twenty-four hours, the wind changing alternately from south to west, and backing again to the south: this alternation of winds continues until the mercury rises to a bold elevation, when it ceases, and the weather becomes settled.

Storms of wind, especially when accompanied with much rain, produce the greatest depressions of the mercury. No storm of wind on record has blown without some rain falling, although the time of its falling and its amount have been variable: sometimes the rain has increased with the increasing storm and sinking mercury; at other times the rain has fallen suddenly at the close of the storm, or at the time of the *minimum* pressure.

No great storm ever sets in with a steady rising barometer.

As far as regards the locality of Greenwich, the most violent gusts of wind come from due south, and those

next in violence from due north; in both instances the mercury remains stationary at its *minimum* point during the greatest *horizontal pressure*: the winds from these quarters are of short duration, and limited in their extent. The ordinary south-west gales will blow unremittingly for twenty-four hours, and will sweep over the whole of the British Isles.

Note. Although a rising mercury attends a northerly wind, great depressions occur previously to a great storm coming from that quarter.

In England, the winds which blow for the greatest number of days together without intermission, are the west and west-south-west: they blow chiefly during the winter months, and are the principal cause of our mild winters.

The east and east-north-east are the winds the next most prevalent. The great antagonist winds, the north and south, are the origin of our most violent storms.

The westerly winds surge mostly by night, and their average force is twice that of the easterly winds.

The easterly winds are generally calm at night, but blow with some power during the day.

On an average, sunrise and sunset are the periods of the twenty-four hours in which there is the least wind. An hour or two after noon is the period when the wind is the highest.

As a general rule, when the wind turns against the sun, or *retrogrades* from west to south, it is attended with a falling mercury; when it goes in the *same direction* as the sun, or turns direct from west to north,

the mercury rises, and there is a probability of fine weather.

It never hails in calm weather. When hail falls, it is during sudden gusts of wind, and the mercury rises while the hail is actually falling.

If the weather during harvest-time has been generally fine, and a fall of the mercury with a shower occur,—if the wind turn a few points to the north and the barometer rises above 30 inches, the weather may be expected to be fair for some days.

When there is only one current of air subsisting in the atmosphere, there is seldom much variation in the height of the mercurial column. It is when two or more *strata* of the air are in motion in different directions at the same time, that great fluctuations of the mercury occur.

In high pressures, the *upper* current usually sets from the northward; in low pressures it sets from the south and south-west.

The variations of the barometer are always greater in the winter than in the summer.

Of the Clouds.

Howard's Nomenclature.

Cirrus.	Cumulo-Stratus.
Cirro-Stratus.	Stratus.
Cirro-Cumulus.	Nimbus.
Cumulus.	Scud.

The *Cirrus* cloud is seen at all seasons of the year, and at all heights of the barometer. It occupies the most elevated regions of the atmosphere, and is supposed to be above the limit of perpetual congelation (in our *latitude* about 6000 feet). It is easily distinguished from all other clouds by its delicate, fibrous, thread-like, curling or feathery texture; it lies in light patches on the blue sky, sometimes so faintly that the eye can scarcely discern it; its motion is very slow, and in serene weather with a high pressure it will retain its form unaltered for many hours. If the mercury be falling, its changes are rapid; and on the approach of rain its delicate texture becomes confused, and is ultimately lost in one dusky mass, resembling *ground glass*. During these changes the Cirrus has been descending; and its peculiar characteristics having disappeared, it assumes a new nomenclature, the Cirro-Stratus. The progressive increase of the Cirrus cloud is generally from the west.

The *Cirro-Stratus* is likewise in the higher regions of the atmosphere, and is seen at all seasons of the year: it is the immediate precursor of rain or wind and of a *falling* barometer. Sometimes it spreads itself over the heavens so attenuated, that the sun, though it shines through it, casts its shadows indistinctly; at other times it spreads itself in lurid darkness, threatening storm and tempest, but terminating in rain or wind. If, after a rapid rise in the mercury, this cloud make its appearance in bars, or streaks which seem to converge in the horizon, rain shortly follows. It is in the Cirro-

Stratus cloud that *halos, parhelia, paraselenæ,* &c. are formed.

The *Cirro-Cumulus,* or warm-weather cloud, attends a *rising* barometer. This pretty modification is often formed from the *Cirrus.* The *Cirro-Stratus* will also frequently after rain dissolve into *Cirro-Cumulus,* an indication that the frozen mass of which the *Cirro-Stratus* is formed is thawed on its descent into a warmer atmosphere; where becoming attenuated, it breaks and splits, leaving clear blue sky between the small round patches of cloud, which take the name of *Cirro-Cumulus.* This cloud is often seen alone in the higher regions; it then assumes a dappled appearance, or what is popularly called a mackerel-back sky. *Coloured Coronæ* have their origin in this cloud.

The *Cumulus* cloud is seen chiefly in the spring and summer months. Its form, when viewed sideways, increases from above in dense, convex heaps; in showery weather it is tufted with the Cirro-Stratus, and in the interval of the showers its texture is fleecy and its form changes rapidly. In hot weather it often appears stationary with a flattened base, its rock-like summits shining with a silvery light. If during a fine morning this cloud suddenly disappear, and it be followed by the Cirro-Stratus cloud with the wind backing to the south, the mercury falls, and rain soon follows.

The Cumulus is the day cloud: its great density keeps off the too scorching rays of the noonday sun; it usually evaporates an hour or two before sunset. When it increases *after* sunset, and shines with a ruddy cop-

per-coloured light, it denotes a thunder-storm. The Cumulus frequently attends a rising barometer. The Cumulus is uncommon during the winter months.

The *Cumulo-Stratus* cloud is most frequent in the spring and summer months. It indicates thunder-gusts, showers of hail and sudden changes of the wind. It is the densest modification of cloud, and as it passes overhead it causes a reduction of temperature. Its form is compounded of the rocky Cumulus, the Cirro-Stratus and Cirro-Cumulus; its texture is puckered or corrugated, and before thunder it becomes deeply fringed, so that it appears to touch the ground. It forms the basis of great thunder-storms, its electrical character attracting clouds and scud from all quarters of the heavens, which uniting confusedly, constitute that indescribable black mass always antecedent to storms of thunder and lightning.

The effect of the Cumulo-Stratus cloud on the mercury appears to be to give it a tendency to rise.

The *Nimbus* is a modification of the Cumulo-Stratus cloud seen in profile during a shower. Its course can be distinctly traced on land, by the dark mist occasioned by the rain then actually falling. The Nimbus is never seen with the barometer at great elevations.

The rainbow is the lovely attendant of the Nimbus cloud *only*.

The *Stratus* is the cloud nearest the ground. It is formed from the sudden chill of certain strata of the atmosphere, which condensing the vapour contained in them, renders it visible in a misty cloud or creeping fog. Calm

weather is essential to the formation of the Stratus; it is frequent in fine autumnal nights and mornings, sometimes resting on the ground, sometimes hovering some hundred feet above it. It obscures the sun until his rays have raised the temperature of the air sufficiently to evaporate it, when it gradually disappears and leaves a clear blue sky. The Stratus deposits moisture: and when the temperature, from radiation or other causes, sinks below 32°, we find it fettered in icy spiculæ upon trees and shrubs, and sparkling in exquisite frostwork upon all nature.

The Stratus is called the night cloud, and is most frequent from September till January. It has no sensible effect on the barometer.

Scud is, with the exception of the *Stratus*, the lowest cloud. It is most commonly seen during the winter months, with every wind that blows and with all pressures of the atmosphere. It always moves in the direction of the wind, and apparently with great rapidity. It is more frequently seen after rain than at any other period. In our westerly gales in winter, it continues for days together, deforming the sky with its large, loose, shapeless masses.

It is not uncommon to observe two or three *strata* of clouds moving in different directions; the *lowest* follows the direction of the wind blowing at the time near the surface of the earth; the *upper* strata follow the currents in the upper regions of the atmosphere; which may be in opposite directions. Before thunder and heavy rain this is of usual occurrence, the barometer at the time being low or in a falling state.

In hot sultry weather, especially after a slight fall of the mercury, small clouds sometimes suddenly form on a clear blue sky, and as suddenly vanish; this is a sure sign of electricity. If the clouds are without any progressive motion and increase rapidly, a storm will in all probability be in the vicinity; but if they move hurriedly towards any particular quarter of the heavens, the storm will be in the direction whither the clouds are seen to hasten: these signs of thunder are seen, though the storm may be 150 miles distant.

Much has been accomplished towards gaining a knowledge of the forms and modifications of the clouds by the classification of Luke Howard. Still, in certain states of the atmosphere, when the clouds mix confusedly and change their forms abruptly, it is difficult for the inexperienced to class them; the prevailing modification of the day, in connexion with the movement of the barometer, is however sufficient to establish the character of the weather.

The splendid crimson contrasting with the delicate azure of a fine autumnal sunset, and the golden flood encroaching upon the deep blue of a summer's sunrise, are chiefly referable to the lofty Cirrus and Cirro-Cumulus clouds. Perhaps no climate in the temperate zone can boast, during the fine period of the year, of clouds of so many beautiful and so varied forms as Great Britain. They are the production of Great Nature's hand, and are anticipated with equal delight by the painter, the meteorologist and the contemplative mind.

A Table showing the average quantity of Rain at Greenwich, Kent, for each month of the year, deduced from twenty-five consecutive years from 1815 *to* 1839.

Month of the year.	Average quantity of rain for each month.	Greatest quantity of rain recorded in one month.	Least quantity of rain recorded in one month.
January	1·57	4·833	0·30
February	1·56	3·690	0·04
March.....	1·71	3·450	0·40
April	1·83	4·790	0·06
May	2·01	4·160	0·50
June	1·91	4·260	0·59
July	2·41	6·650	0·10
August	2·33	4·655	0·07
September	2·50	4·795	0·65
October	2·52	5·070	0·53
November	2·49	4·330	0·85
December	2·25	4·540	0·08
Mean annual depth...	25·09		

From the above synopsis, it appears that the greatest average quantity of rain falls in October and the least in February.

The heaviest rains, or those which yield the greatest quantity in the gauge, come down in the summer and early autumnal months. In the summer an inch and a half will sometimes fall in less than an hour in short but impetuous torrents; in the autumn the same quantity will occupy many hours in falling.

In winter the number of wet days exceeds that of the summer period; the average fall of a winter's rain is seldom more than $\frac{1}{10}$ of an inch an hour.

The amount of snow for the twenty-five years is included in the above table.

Snow yields $\frac{1}{10}$ of water to 1 inch fall in depth; or a fall of snow of 10 inches in depth on the level would be equal to 1 inch of rain.

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* *The following Table and Theorem are from Sir George Shuckburgh, and will show how the Barometer is used for ascertaining the Height of Mountains.*

TABLE I.

Thermometer.	Feet.
32°	86·85
35	87·49
40	88·54
45	89·60
50	90·66
55	91·72
60	92·77
65	93·82
70	94·88
75	95·93
80	96·99

Explanation of Table I.

This table gives the number of feet in a column of the atmosphere equivalent in weight to a like column of mercury $\frac{1}{10}$ of an inch high, when the barometer stands at 30 inches, for every 5 degrees of temperature ranging

* To perform this operation accurately, two persons should take contemporary observations with two barometers and thermometers, the one at the bottom of the hill and the other at the top.

from 32° to 80°; and from this Table II. has been constructed as more convenient for general use:—

TABLE II.

Thermometer.		Thermometer.		Thermometer.	
30°	864·4	47°	900·2	64°	936·1
31	866·5	48	902·3	65	938·2
32	868·5	49	904·5	66	940·3
33	870·6	50	906·6	67	942·4
34	872·7	51	908·7	68	944·5
35	874·9	52	910·8	69	946·7
36	877·0	53	913·0	70	948·8
37	879·2	54	915·1	71	950·9
38	881·3	55	917·2	72	953·0
39	883·4	56	919·3	73	955·1
40	885·4	57	921·4	74	957·2
41	887·5	58	923·5	75	959·3
42	889·6	59	925·6	76	961·4
43	891·7	60	927·7	77	962·5
44	893·8	61	929·8	78	965·6
45	896·0	62	931·9	79	967·7
46	898·1	63	934·0	80	969·9

Rule.

Let x = height of mountain required.

A = the mean height of the two barometers in inches.

a = the *difference* of the two.

b = the number in Table II. corresponding to the mean height of the two thermometers.

(Barometer at 30 inches.)

$$\text{Then } x = \frac{30^{\text{in.}} \times ab}{A}.$$

Example.

Suppose the barometer at the bottom of the mountain to stand at 30 inches, thermometer 60°; the barometer at the top 26·36 inches, thermometer 46°; required the height of the mountain, say Snowdon. The mean of the two barometers, or A, is 28·18 inches; their difference, or *a*, 3·64 inches; and the mean of the two thermometers, or *b*, 53°. In Table II. 913·0 is opposite to 53°; therefore

$$\frac{30 \times 3{\cdot}64 \times 913{\cdot}0}{28{\cdot}18} = 3538{\cdot}0 \text{ feet.}$$

Table of Factors for deducing the Dew-point from the temperature of the air and the temperature of evaporation. (*From the "Greenwich Magnetical and Meteorological Observations,"* 1844.)

Readings of the dry-bulb thermometer.	Factor.
Between 28° and 29°	5·7
... 29 ... 30	5·0
... 30 ... 31	4·6
... 31 ... 32	3·6
... 32 ... 33	3·1
... 33 ... 34	2·8
... 34 ... 35	2·6
... 35 ... 40	2·4
... 40 ... 45	2·3
... 45 ... 50	2·2
... 50 ... 55	2·1
... 55 ... 60	1·9
... 60 ... 70	1·8
... 70 ... 80	1·7
... 80 ... 85	1·6
... 85 ... 90	1·8

These factors vary from those of Mr Glaisher use

Rule.

Multiply the difference between the two thermometers by the *factor* corresponding to the temperature of the dry-bulb thermometer, and subtract the product from it; the remainder will be the temperature of the dew- or vapour-point.

Let dry-bulb thermometer $=66^{\circ}$
Let wet-bulb thermometer $=57$
Difference $=\cdot 9$
$1{\cdot}8$
Product $=16{\cdot}2$

$66^{\circ}-16{\cdot}2=49^{\circ}{\cdot}8=$ dew-point.

Dr. Apjohn's formula for finding dew-point is—

Above 32°. $f''=f'-\frac{d}{88}\times\frac{h}{30}$ Below 32°. $f''=f'-\frac{d}{96}\times\frac{h}{30}$.

Where

f'' represents the force of aqueous vapour at temperature of dew-point.

f' represents the force of vapour at temperature of evaporation.

d represents the difference between dry and wet thermometers.

h height of barometer.

A Table showing the elastic force of aqueous vapour for every degree of Fahrenheit from 0° to 80°.

Thermometer. Fahrenheit.	Force of aqueous vapour.	Thermometer. Fahrenheit.	Force of aqueous vapour.	Thermometer. Fahrenheit.	Force of aqueous vapour.
°	in.	°	in.	°	in.
0	0·061	27	0·167	54	0·428
1	·064	28	·173	55	·442
2	·066	29	·179	56	·458
3	·069	30	·186	57	·473
4	·071	31	·192	58	·489
5	·074	32	·199	59	·506
6	·077	33	·207	60	·523
7	·080	34	·214	61	·541
8	·083	35	·222	62	·559
9	·086	36	·230	63	·578
10	·089	37	·238	64	·597
11	·093	38	·246	65	·617
12	·096	39	·255	66	·638
13	·100	40	·264	67	·659
14	·104	41	·274	68	·681
15	·108	42	·283	69	·704
16	·112	43	·293	70	·727
17	·116	44	·304	71	·751
18	·120	45	·315	72	·776
19	·125	46	·326	73	·801
20	·129	47	·337	74	·827
21	·134	48	·349	75	·854
22	·139	49	·361	76	·882
23	·144	50	·373	77	·910
24	·150	51	·386	78	·940
25	·155	52	·400	79	0·970
26	0·161	53	0·414	80	1·001

A Table of the velocities and pressures of the Wind.

Miles per hour.	Force in lbs. on square foot.	
5	0·12	Gentle breeze.
10	0·49	A brisk gale.
15	1·11	
20	1·97	Very brisk.
30	4·43	High winds.
35	6·03	
40	7·87	Very high.
45	9·96	
50	12·30	A storm.
60	16·71	A great storm.
80	31·49	Tears up trees and destroys all before it.
100	49·20	

Depression of Mercury in glass tubes, or corrections to be added *for capillary attraction.*

Diameter of tube.	
in.	in.
0·25	0·020
0·30	0·015
0·40	0·007
0·45	0·005
0·60	0·002

Corrections for Temperature to be applied

Temp. of Fahr.	Inches. 24·5	Inches. 25·0	Inches. 25·5	Inches. 26·0	Inches. 26·5	Inches. 27·0
°						
24	+·010	+·010	+·010	+·011	+·011	+·011
26	·006	·006	·006	·006	·006	·006
28	+·001	+·001	+·001	+·001	+·001	+·001
30	−·003	−·003	−·004	−·004	−·004	−·004
32	·008	·008	·008	·008	·008	·008
34	·012	·012	·013	·013	·013	·013
36	·017	·017	·017	·017	·018	·018
38	·021	·021	·022	·022	·023	·023
40	·025	·026	·026	·027	·027	·028
42	·030	·030	·031	·031	·032	·033
44	·034	·035	·035	·036	·037	·037
46	·038	·039	·040	·041	·042	·042
48	·043	·044	·045	·045	·046	·047
50	·047	·048	·049	.050	·051	·052
52	·052	·053	·054	·055	·056	·057
54	·056	·057	·058	·059	·060	·062
56	·060	·061	·063	·064	·065	·066
58	·064	·066	·067	·068	·070	·071
60	·069	·070	·072	·073	·075	·076
62	·073	·075	·076	·078	·079	·081
64	·078	·079	·081	·083	·084	·086
66	·082	·084	·085	·087	·089	·090
68	·086	·088	·090	·091	·094	·095
70	·091	·093	·095	·096	·098	·100
72	·095	·097	·099	·101	·103	·105
74	·099	·102	·104	·106	·108	·110
76	·103	·106	·108	·110	·112	·114
78	·108	·111	·113	·115	·117	·119
80	−·114	−·115	−·117	−·119	−·122	−·124

Enter with approximate height of the barometer at on the side of the page; then take out the correction

to Barometers mounted on brass scales.

Inches. 27·5	Inches. 28·0	Inches. 28·5	Inches. 29·0	Inches. 29·5	Inches. 30·0	Inches. 30·5	Temp. of Fahr.
+·011	+·011	+·012	+·012	+·012	+·012	+·012	24°
·006	·006	·006	·007	·007	·007	·007	26
+·001	+·001	+·001	+·001	+·001	+·001	+·001	28
−·004	−·004	−·004	−·004	−·004	−·004	−·004	30
·009	·009	·009	·009	·009	·009	·010	32
·014	·014	·014	·014	·015	·015	·015	34
·019	·019	·019	·020	·020	·020	·020	36
·023	·024	·024	·025	·025	·026	·026	38
·028	·029	·029	·030	·030	·031	·031	40
·033	·034	·034	·035	·036	·036	·037	42
·038	·039	·040	·040	·041	·042	·042	44
·043	·044	·045	·045	·046	·047	·048	46
·048	·049	·050	·051	·052	·052	·053	48
·053	·054	·055	·056	·057	·058	·059	50
·058	·059	·060	·061	·062	·063	·064	52
·063	·064	·065	·066	·067	·068	·070	54
·068	·069	·070	·071	·073	·074	·075	56
·073	·074	·075	·077	·078	·079	·081	58
·077	·079	·080	·082	·083	·085	·086	60
·082	·084	·085	·087	·088	·090	·091	62
·087	·089	·090	·092	·094	·095	·097	64
·092	·094	·096	·097	·099	·101	·102	66
·097	·099	·101	·102	·104	·106	·108	68
·102	·104	·106	·108	·109	·111	·113	70
·107	·109	·111	·113	·115	·117	·119	72
·112	·114	·116	·118	·120	·122	·124	74
·117	·119	·121	·123	·125	·127	·129	76
·122	·124	·126	·128	·130	·133	·135	78
−·126	−·129	−·131	−·133	−·136	−·138	−·140	80

the top of the table, and the degree of the thermometer with its proper sign.

Corrections for Temperature to be applied to Barometers mounted in wood.*

Temperature.	Inches. 28·5	Inches. 29·0	Inches. 29·5	Inches. 30·0	Inches. 30·5
°					
25	+·017	+·017	+·018	+·018	+·018
26	·015	·015	·015	·015	·015
27	·012	·012	·012	·012	·012
28	·009	·010	·010	·010	·010
29	·007	·007	·007	·007	·007
30	·005	·005	·005	·005	·005
31	+·002	+·003	+·003	+·003	+·003
32	·000	·000	·000	·000	·000
33	−·002	−·002	−·002	−·002	−·003
34	·005	·005	·005	·005	·005
35	·007	·007	·008	·008	·008
36	·010	·010	·011	·011	·011
37	·013	·013	·013	·014	·014
38	·015	·015	·015	·015	·015
39	·018	·018	·018	·019	·019
40	·020	·020	·020	·021	·021
41	·023	·023	·023	·024	·024
42	·025	·025	·025	·026	·026
43	·028	·028	·028	·029	·030
44	·030	·030	·030	·031	·032
45	·032	·032	·033	·033	·034
46	·035	·035	·036	·036	·036
47	·037	·037	·038	·038	·038
48	·039	·039	·040	·040	·040
49	·041	·041	·043	·043	·043
50	·044	·045	·046	·047	·047
51	·047	·047	·049	·049	·050
52	·050	·050	·051	·051	·052
53	·053	·053	·054	·054	·055
54	·055	·055	·056	·057	·058
55	·056	·057	·058	·059	·060
56	·059	·059	·060	·062	·063
57	·062	·062	·062	·064	·065
58	·064	·064	·065	·066	·067
59	·066	·067	·068	·069	·071
60	·068	·069	·071	·072	·073
61	·072	·072	·073	·074	·075
62	−·074	−·074	−·076	−·077	−·078

* The corrections in the above table are due to the expansion of mercury only.

Corrections for Temperature to be applied to Barometers mounted in wood—(continued).

Temperature.	Inches. 28·5	Inches. 29·0	Inches. 29·5	Inches. 30·0	Inches. 30·5
°					
63	—·077	—·077	—·078	—·080	—·081
64	·080	·080	·081	·083	·084
65	·081	·082	·083	·085	·086
66	·084	·085	·086	·087	·088
67	·088	·088	·089	·090	·091
68	·090	·090	·091	·093	·094
69	·092	·092	·093	·095	·097
70	·093	·094	·096	·098	·100
71	·096	·097	·098	·100	·102
72	·099	·099	·101	·103	·105
73	·102	·102	·103	·106	·108
74	·104	·105	·106	·108	·111
75	·105	·107	·109	·112	·114
76	·107	·109	·112	·115	·117
77	·110	·112	·114	·117	·120
78	·112	·114	·117	·120	·123
79	·115	·117	·120	·123	·127
80	—·117	—·119	—·122	—·126	—·130

Enter at the top of the table with the approximate height of the barometer, and on the left side of the page with the degree of the thermometer; take out the correction with its proper sign. In this table all corrections above 32° are to be subtracted.

	in.
Let barometer read . .	29·500—therm. attached = 68°
Correction by table . .	—·091
Correct height for 32°	29·409

THE ANEROID BAROMETER.

A new instrument, the *Aneroid* Barometer, has lately been invented by M. Vidi of Paris, for ascertaining the variations of the atmosphere: its action depends on the effect produced by the pressure of the atmosphere on a metallic box from which the air has been exhausted and then hermetically sealed. It has already been explained that the weight of the column of the mercurial barometer is conterpoised by the weight of the atmosphere, and that the variations in the weight of the atmosphere are shown by the variations in the *length* of this column, and measured in inches and tenths; but in the Aneroid an index traversing a dial records the changes in the weight or *pressure* of the atmosphere on a *given surface*, suppose a square inch; it would therefore have greatly facilitated the comprehension of the action of the instrument had the dial been graduated to show the difference of the atmospheric pressure, in absolute weight or pounds. Though for purely scientific purposes the Aneroid is at present far removed from competition with the mercurial barometer, it nevertheless has some advantages in its extreme sensibility and its portability. Much has been urged against its variations from temperature; the writer has made experiments with his own instrument and with many sent him for comparison by Messrs. Watkins and Hill: in a range of temperature from 28° to 80°, the variations have seldom exceeded a tenth of an inch; and it must be borne in mind, that had the mercurial barometer been subjected to the same range, it would have been equally affected, only in the latter case the

cause of the variation is satisfactorily established, and its exact amount for every degree of temperature accurately determined; whereas in the former case the cause requires further explanation. Of how little importance this explanation is for the popular use of the Aneroid, the following observations will show.

Simultaneous observations of the Aneroid and Mercurial Barometer for the month of March 1848.

Date.	9 A.M.		Thermometer.	3 P.M.		Thermometer.
	Aneroid barometer.	Standard barometer.		Aneroid barometer.	Standard barometer.	
			°			°
1.	28·66	28·67	50	28·80	28·80	50
2.	29·15	29·15	50	29·29	29·29	50
3.	29·88	29·90	48			
4.	30·12	30·14	46	30·11	30·12	51
5.	29·82	29·83	46	29·77	29·77	46
6.	29·87	29·88	46	29·84	29·85	47
7.	29·81	29·82	45			
8.	30·28	30·29	44	30·22	30·25	46
9.	29·98	29·99	49	29·89	29·90	52
10.	29·44	29·45	51	29·41	29·42	51
11.	28·91	28·93	50	28·84	28·85	50
12.	28·69	28·70	48	28·79	28·80	48
14.	29·76	29·78	47	29·85	29·88	49
15.	29·76	29·78	46	29·64	29·65	49
16.	29·49	29·50	48	29·49	29·49	49
17.	29·34	29·35	49	29·34	29·34	46
18.	29·44	29·45	46	29·37	29·37	52
19.	29·18	29·20	48	29·12	29·12	51
20.	28·98	28·99	48	28·97	28·98	49
21.	28·80	28·81	49	29·13	29·13	49
22.	29·60	29·60	47	29·67	29·68	51
23.	29·67	29·70	54	29·80	29·80	54
24.	30·02	30·02	55	30·10	30·10	55
25.	30·16	30·16	52	30·11	30·11	54
26.	29·89	29·90	53	29·80	29·80	54
27.	29·70	29·70	53	29·70	29·70	56
29.	29·91	29·91	54	29·91	29·90	56
30.	29·81	29·80	55	29·81	29·80	58
31.	29·98	29·98	58	30·00	30·00	65

The instrument has always been thus coincident since the writer received it in December 1848 from Messrs. Watkins and Hill.

The next series of observations, showing the portability of the Aneroid for measuring heights, and also its convenience as a meteorological barometer, were taken during an excursion into Wales in the summer of 1848.

London to Chester (*vid* Trent Valley) Stations.	Readings of the Aneroid Barometer.
August 10th.	
Davies Street, Berkeley Square	30·05
Harrow station	29·85
Tring (highest ground)	29·71
Cheddington	29·82
Wolverton	29·89
Blisworth	29·78
Weedon	29·83
Rugby	29·82
Atherstone	29·90
Norton Bridge	29·90
Chester, St. Peter's Churchyard	30·11
August 11th.	
Railway viaduct over the Dee at Chester	30·14
Upon a hill on the coach-road from Ruabon to Llangollen.	29·69
Llangollen Bridge	29·91

Llangollen is assumed to be about 200 feet higher than the Estuary of the Dee near Chester.

Elevations. August 12, 13 and 18.		Before going out	Return home
		at Llangollen.	
Castle Dinas Bran	29·02	29·92	29·90
Rising ground to S. of Barber's Hill	28·75	29·87	29·81
A high hill S.W. of Llangollen, 2 miles, and marked down in Ordnance Map *Grouse Box*	28·24	29·89	29·70
Very high ground west of *Grouse Box* and leading to *Moel Ferna*, situated in *Berwyn Chain*	28·02	29·89	29·70

Journal of the Weather at Llangollen, Denbighshire.

1848.	Aneroid barometer, 9 A.M.	Therm. in shade, 9 A.M.	Aneroid barometer, 3 P.M.	Therm. in shade, 3 P.M.	Aneroid barometer, 9 P.M.	Thermometer, 9 P.M.	Wind.	Weather, &c.
Aug.		°		°		°		
12.	29·92	62	29·90	64	...	...	N.W.	Fair.
13.	29·87	59	...	65	29·81	...	E.S.E.	Ditto; evening cloudy.
14.	29·76	52	29·74	51	29·72	50	E.	Incessant rain.
15.	29·77	55	29·76	60	29·75	...	E.	Cloudy.
16.	29·70	55	29·70	67	29·72	58	S.E.	Fair; heavy rain all night.
17.	29·65	57	29·68	59	29·85	49	E.	Rain and wind till 3 P.M.
18.	29·89	61	29·70	57	29·58	57	S.S.E.	Fine A.M.; evening and night
19.	29·51	59	29·58	62	29·62	56	W.	Fine. [incessant heavy rain.
20.	29·73	63	29·75	64	29·76	58	S.W.	*Nimbi*; rain in torrents at night.
21.	29·195	52	(29·09*—)	57	29·32	54	W.	Destructive tempest, with
22.	29·35	...	29·36	...	...	...	W.	Showery. [small rain.
23.	29·51	...	29·58	59	...	58	W.	Heavy showers; lightning and
24.	29·77	...	...	...	...	...	W.	Heavy showers. [rain at night.
25.	...	...	29·87	...	...	...	W.	Fine.

16. A brilliant parhelion, seen to the right of the sun about 6 P.M. The *true* sun behind a mountain, in a cloud.

21. This storm exceeded any on record since January 1839; many hundred trees were either partly or wholly destroyed; the spray of the river Dee at *Llangollen* was, during some of the most violent gusts, carried higher than the adjacent houses, and the noise of the waters resembled the roar of thunder.

22. The Dee much swollen; the waters rush down their rocky bed with impetuosity.

* About the *minimum* point, which continued for 3 *hours*. By temporary gauge, the quantity of rain fallen estimated at 5 inches for the 14 days.

Journal of the Weather at Hastings.

1848.	9 A.M.		9 P.M.		Wind.	
Aug. 31.	...	...	30·20	60	N.E.	Fine. Lightning to S.W. & N.E. evening
Sept. 1.	30·31	...	30·42	52	E.N.E.	Fine. [and night.
2.	30·55	...	30·56	60	W.N.W.	*Cumuli*; calm; very fine.
3.	30·56	...	30·52	58	...	Dead calm and clear; sea perfectly still.
4.	30·39	...	30·22	...	S.E.	Clear.
5.	30·05	...	29·96	66	S.	Fine; appearance of thunder to S.W.
6.	30·03	...	30·17	59	W.	A breeze; *scud*; fine night.
7.	30·22	...	30·22	61	W.S.W.	Clear day succeeded by a cloudy night.
8.	30·18	60	...	...	W.	Cloudy.

Sept. 6. Near the windmill on the top of Fairlight Down 29·44
Reading—before going out 30·03
Reading—return home ... 30·07
} Temperature about 65°.

On the 8th of September the instrument was again suspended in its usual place at Greenwich, and it was found that the *zero point* had remained perfectly steady*.

In consulting the above journal, we find that the movements of the Aneroid were always consistent. It was a delightful companion, and highly useful, its indications preventing many an excursion which would have ended in disappointment. The tourist should never travel without it; and the seaman will find it a safe guide when the motion of the mercurial column renders the marine barometer almost useless. In all cases the

* *Note.*—All the foregoing observations were made for amusement. The beautiful action of the instrument, however, was an inducement to offer them for publication to a literary journal; but the subject not being suited to their columns, they were not inserted.

writer has *used* the Aneroid as its inventor intended it *should be used*; and its movements are so far perfect, that they merit the calm and impartial investigation of the *true* philosopher, whose vocation is to aid the development of ingenuity, and not to crush its efforts because they are not perfection.

The following diagrams are by Mr. Redwood, and the explanation of the Aneroid is nearly the same as that communicated by the same gentleman to the Pharmaceutical Society.

Fig. 1.

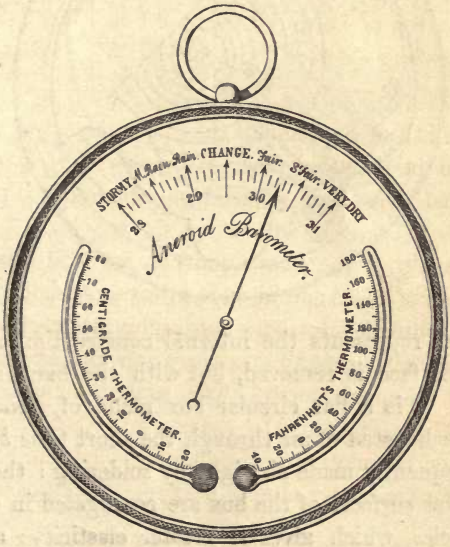

Fig. 1 represents the external appearance of the instrument. It is four inches and three-quarters in dia-

meter across the face, and one inch and three-quarters in thickness. The pressure of the atmosphere is indicated by a hand pointing to a scale, which is graduated to correspond with the common barometer: thermometers are placed on the face, one of which is essential.

Fig. 2.

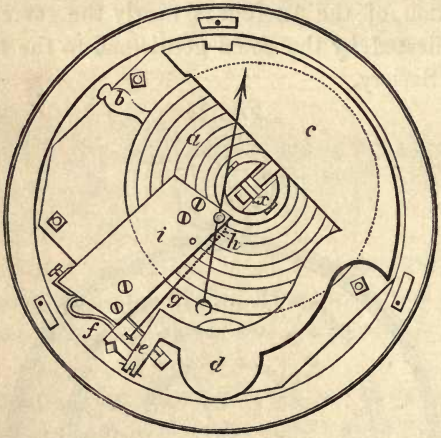

Fig. 2 represents the internal construction as seen when the face is removed, but with the hand still attached. *a* is a flat circular box made of some white metal, exhausted of air through the short tube *b*, which is subsequently made air-tight by soldering: the upper and lower surfaces of the box are corrugated in concentric circles, which gives it greater elasticity; and the box is fixed to the bottom of a metallic case, which incloses the mechanism of the whole instrument. In the

centre of the *upper* surface of the elastic box is a solid cylindrical socket *x*, about half an inch high, to the top of which the *principal lever, c, d, e,* is attached; this lever, which brings the box into a state of tension by separating the surfaces, rests partly on a spiral spring *d*, and partly on two fulcrums having knife-edges, with perfect freedom of motion; the end *e* of the large or principal lever is attached to a second lever *f*, from which a fine watch-chain *g* extends to *h*, where it works on a drum attached to the arbour of the hand; a hair spring at *h*, the attachments of which are made to the metallic plate *i*, regulates the motion of the hand.

As the weight of the atmosphere is increased or diminished, so is the surface of the corrugated elastic box depressed or elevated, as is also at the same time the spiral spring *d*, upon which the principal lever rests; and this motion is communicated through the levers to the arbour of the hand at *h*. The tension of the box in its construction is equal to 44 lbs. At the back of the Aneroid is a screw to adjust the hand to the height of any standard mercurial barometer: for comparative observations the Aneroid must be placed in the position for which the adjustment is made.

The height of the Atmosphere being assumed at 27·500 *feet, with the Barometer at* 30·00 *inches and the Thermometer at* 55° *of Fahrenheit, the following Table of Elevations has been computed, answering to the corresponding depressions of the mercury in the Barometer.*

Height of the barometer.	Feet.	Height of the barometer.	Feet.
in.		in.	
30·0	0	27·3	2592
29·9	92	27·2	2692
29·8	184	27·1	2793
29·7	276	27·0	2895
29·6	368	26·9	2997
29·5	462	26·8	3099
29·4	556	26·7	3201
29·3	650	26·6	3304
29·2	744	26·5	3406
29·1	838	26·4	3511
29·0	933	26·3	3615
28·9	1028	26·2	3719
28·8	1123	26·1	3824
28·7	1219	26·0	3926
28·6	1315	25·0	5000
28·5	1411	24·0	6111
28·4	1508	23·0	7263
28·3	1605	22·0	8462
28·2	1702	21·0	7907
28·1	1799	20·0	11000
28·0	1897	19·0	12345
27·9	1996	18·0	13750
27·8	2095	17·0	15214
27·6	2194	16·0	16740
27·5	2392	15·0	18335
27·4	2491	10·0	27500

The following rule, which gives results very near the truth, will be useful in deducing elevations from the Aneroid.

As the *sum* of the readings of the barometer or Aneroid is to their *difference,* so is 55·000 (or twice the height of the atmosphere in feet) to the elevation required.

To find the height of Fairlight Down near Hastings,

	in.	in.
Let the reading of the Aneroid on the Marine Parade, Hastings.....	=30·05	30·05
... ... at the bottom of the windmill on the Down	=29·44	29·44
Sum...	=59·49	0·61 = difference.

in. in. feet. feet.
∴ 59·49 : 0·61 :: 55·000 : 564 nearly.

The table of elevations computed by the above formula at the temperature of 55°, and the lower barometer at 30 inches, may be found interesting to those who may wish to see at a glance the heights corresponding to the depressions of the barometer.

Thus on the Grampian Hills a depression of 4 inches gives an elevation of 4000 feet; at the crater of Mount Etna a depression of 10 inches gives 11,000 feet; and on the summit of the mountains of Thibet, supposed the loftiest in the world, a depression of 20 inches gives an elevation of 27,500.

THE END.

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